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REVISION OF THE PALÆOCRINOIDEA.

BY CHARLES WACHSMUTH AND FRANK SPRINGER.

PART II.

FAMILY SPHÆROIDOCRINIDÆ,

INCLUDING THE SUB-FAMILIES

PLATYCRINIDÆ, RHODOCRINIDÆ, AND ACTINOCRINIDÆ.

The first part of this work was published contemporaneously with the "3d Lieferung" of Professor Zittel's "Handbuch der Palæontologie," which embraces the Crinoidea.

In his classification, this distinguished author follows Johannes Müller, and divides the Crinoidea into three orders: *Eucrinoidea* (*Brachiata*, Müller), *Cystoidea*, and *Blastoidea;* subdividing the first into the Tesselata, Articulata, and Costata. The "Tesselata" agree in general features with our *Palæocrinoidea*, and the Articulata with the mesozoic and recent Crinoids, for which we have proposed the name *Stomatocrinoidea;* but while we treat these groups as of the same rank with the Blastoidea and Cystoidea, they are, according to Müller and Zittel, mere subdivisions of the "*Brachiata.*"[1]

Zittel divides the Tesselata into twenty-six families, among which his Ichthyocrinidæ and Taxocrinidæ substantially agree with our Ichthyocrinidæ, except that he included among the Taxocrinidæ the genera *Lecythocrinus* and *Gissocrinus*, which we refer to the Cyathocrinidæ. Our Cyathocrinidæ include his Poteriocrinidæ, Heterocrinidæ, Cyathocrinidæ and Hybocrinidæ, except that he places among the first of these families, *Agassizocrinus* and *Belemnocrinus*, which we think belong to other families.

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[1] While this was in press, we received from Dr. Etheridge, Jr., and P. Herb. Carpenter, an interesting paper upon the genus *Allagecrinus*, a new form from the Carboniferous of Scotland, which they consider to be "tesselate" in the younger, "articulate" in the adult state. In a discussion upon Müller's terms, *Tesselata* and *Articulata*, they arrive at the conclusion, that at the present state of our knowledge of these Crinoids those names are inappropriate and should be abandoned. They adopt our name *Palæocrinoidea*, but object to *Stomatocrinoidea*, as they think it possible, that also Crinoids of the other group might have possessed an external mouth. They consider the irregular arrangement of the plates in the calyx, against the almost perfect symmetry which is found throughout the other group, and the vault structure, to be better and more persistent characters for distinction than the condition of the mouth. We can only notice here this important paper, but shall take pleasure to refer to it at some future time.

Zittel's classification, in its general results and conclusions, does not differ materially from our own; but instead of subdividing the Palæocrinoidea at once into a number of small groups which he calls families, we separate them at first into comparatively few well-marked groups, which we subdivide when necessary. Our families are not based upon mere differences in the arrangement of the plates, but are expressions of important modifications in the structure of the animal, which must have affected the whole organism, and consequently form the basis of well defined natural divisions.

The groups which we recognize as Ichthyocrinidæ, Cyathocrinidæ and Sphæroidocrinidæ existed at the beginning of the geological record, and flourished side by side until they became extinct. They are so well defined by nature, that once understood there is no difficulty in identifying them. The smaller groups into which we have divided the Sphæroidocrinidæ, are likewise of early origin, but they follow more or less the same general plan in the arrangement of their plates, as well as in their mode of development, individually and paleontologically.

There have been several interesting publications on Crinoids during the past year, containing, among others, descriptions of new species of both Ichthyocrinidæ and Cyathocrinidæ. These species will be noticed and systematically arranged in an appendix at the end of this work.

We are under special obligations to Prof. Spencer F. Baird for access to a number of rare and valuable books in the Smithsonian Library; to Dr. C. A. White, of the National Museum, for numerous favors received during the preparation of this work; to Prof. A. H. Worthen, of Springfield, Ill., and to a number of other gentlemen for the liberal loan of books and specimens, and for other valuable information.

III.—SPHÆROIDOCRINIDÆ.

The above name is proposed as a family designation, to include such forms of the Palæocrinoidea, in which both calyx and vault are constructed of a large number of immovable plates and these forming inflexible walls; with several orders of radials, and one or more of interradials on both the oral and aboral sides. The Sphæroidocrinidæ differ thus conspicuously from the Ichthyocrinidæ with their flexible walls and squamous vault, and from the Cyathocrinidæ with their uniform elements of three rings of plates in the calyx, without interradials, and with simple oral plates in the vault.

The family, as thus defined, will include genera with underbasals, and genera without them. In this we differ from most authors, who make the presence or absence of these plates a marked family distinction, and who place together within the same family Cyathocrinidæ, Ichthyocrinidæ and Rhodocrinidæ.

Pictét, Traité de Paléontologie, vol. iv, included in his "Cya thocriniens" our Cyathocrinidæ, Rhodocrinidæ and partly our Ichthyocrinidæ; from the former, however, he excluded *Graphiocrinus*, which had been described by De Koninck and Lehon with a single circle of plates beneath the radials, and from the latter *Forbesiocrinus* and *Taxocrinus*, in which underbasals had not been discovered; while he admitted the allied genera *Ichthyocrinus*, *Lecanocrinus* and *Mespilocrinus* in which they had been observed. Similar opinions were held by d'Orbigny, Hall, Miller, Austin and others, not including, however, Roemer and Schultze, who made the Rhodocrinidæ a distinct family.

In the first part of this work we have discussed somewhat fully the relations of the underbasals, which we took to be the product of growth in geological times, introduced gradually by interpolation between the basals. It is very remarkable that, although the introduction of underbasals dates back to the Lower Silurian, as a rule, the genera in which those plates are found differ at no time materially from those in which they are wanting. Even as late as the Subcarboniferous, we find such species as *Actinocrinus Whitei*, and *Rhodocrinus Wachsmuthi*, both from the Burlington limestone, so strikingly similar in every respect, both in the structure of the body and arms, that the species cannot be separated except by means of the basal portions. There are similar examples in the Silurian and Devonian, which will be noticed later.

If, therefore, it be true that the underbasals had no important bearing or influence upon the general structure of the Crinoids, there is no good reason for making their presence or absence a family character, and basing thereon a division to rank with the Cyathocrinidæ and Ichthyocrinidæ, whose fundamental structural plans offer broad and unmistakable distinctions. Nevertheless, they are not without importance in classification, and certainly characterize a group of more than generic value. We have accordingly brought together the genera of this family in which these plates exist under the name "*Rhodocrinidæ.*"

The great family Sphæroidocrinidæ includes a vast variety of forms, and a mere separation of these into genera does not meet the requirements of a systematic classification. We find that the genera fall naturally into groups which are well defined. These subordinate groups, which are three in number, we consider to be sub-families, and have arranged them in the following manner:

1. PLATYCRINIDÆ.—Underbasals wanting; basals and first radials forming the greater part of the calyx; succeeding primary radials very small or rudimentary; all higher orders of radials embraced within free rays; interradial system but little developed.

2. ACTINOCRINIDÆ. — Underbasal wanting; calyx composed of basals; two or more orders of radials; well developed interradial, and often interaxillary series.

3. RHODOCRINIDÆ. — Underbasals present; calyx composed of basals and several orders of radials; interradial system well developed.

Before proceeding to the more detailed consideration of these groups, we will consider the different parts of which the body in the Sphæroidocrinidæ is constructed, and this will throw additional light upon the relations of the subdivisions.

1. UNDERBASALS AND BASALS.

The genus *Glyptocrinus* Hall, from the Lower Silurian is one of the earliest, most beautiful, and most instructive types of the Palæocrinoidea, and fortunately is often found in excellent preservation. Looking at the great number of plates which compose its body, at its elaborate ornamentation, one is naturally inclined to consider this as one of the most maturely developed forms in the whole family, but in other respects, it possesses in a marked degree the characters of the young crinoid of later geologic times.

Glyptocrinus was originally described with five basals and no underbasals. Hall afterwards discovered in *Gl. decadactylus* small pieces concealed within the basal cavity, so rudimentary, however, that both he and Meek hesitated to call them basals, although both authors apply that term to the proximal plates in all other cases. Meek distinguished them as "subbasals." We have examined the plates in question very carefully in the species named, and find them, although very rudimentary, placed within the basal ring, hence they are, according to our terminology, true underbasals, and not as Hall describes them a "quinquepartite" upper joint of the column.[1]

In some other species of this genus the underbasals seem to be altogether wanting, at least are not developed externally. In *Glyptocrinus Dyeri* no trace of them can be discovered, though we have examined with reference to this point, some most perfect specimens. If the underbasals were elements of family importance, *Gl. decadactylus* and *Gl. Dyeri* would be representatives of distinct families.

Glyptocrinus is exclusively a Lower Silurian genus. The two species from the Upper Silurian, referred to it by Hall, have been transferred by us to other genera. One of these, *Mariacrinus Carleyi*, is another interesting case illustrating our view that the underbasals have no important effect upon the general structure of the body. *M. Carleyi* would be an excellent *Glyptocrinus* were it not that the calyx below the radials is composed of a single ring, and this of only four pieces. *Periechocrinus*, like *Mariacrinus* an Upper Silurian genus and like it without underbasals, has instead of four or five basals, only three. In all other respects these genera agree so perfectly with *Glyptocrinus* that they cannot be distinguished, proving again how closely Rhodocrinidæ and Actinocrinidæ are linked together, and that they are in fact variations of one great group.

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[1] The underbasals cannot be developed from a columnar joint, or their sutures would correspond with the sutures of the column; whenever this is divided, the division occurs alternately with that of the underbasals, and as a rule alternately with the proximal ring of plates.

Where underbasals are unrepresented, families have frequently been created upon the number of the basals, and Angelin based his entire classification upon the number of proximal plates, whether basals or underbasals. Convenient as this scheme of classification may seem, it is altogether artificial, and combines forms which are widely different, while it separates others which are clearly allied.

We have in the introduction to this work, page 17, dwelt at some length upon the basals or first ring of plates below the radials; and believe we have shown that the basal disk, whether composed of one, two, three, four or five pieces, can almost invariably be reduced to five elementary pieces, and that all deviations from this number have been produced by anchylosis of two or more of the original segments. This, of itself, is a strong argument against a classification based upon the number of these plates.

Among the Actinocrinidæ, only a few genera with the original five basal plates are known, and these are confined to the Silurian; indeed we have good reason to believe that only the very earliest representatives of this group possess a base divided into five pieces. Genera with four basals commence in the Silurian and terminate in the Devonian; while genera with three basals are found from the Upper Silurian to the close of the Warsaw limestone where the family becomes extinct. The genera with four basals have been referred by us partly to the Actinocrinidæ, and partly to the Calyptocrinidæ. The latter family has four basals throughout, but even here this number cannot be considered a family character, since *Melocrinus* and *Mariacrinus*, which have four basals, belong undoubtedly to the Actinocrinidæ. Species with three basals are found among both Actinocrinidæ and Platycrinidæ, and the latter are by no means restricted to this number, as *Dichocrinus*, which has been by most systematists placed in the same group with *Platycrinus* and *Hexacrinus*, has but two basals.

It is apparent from these facts that neither the existence of underbasals, nor the modifications which took place in the basal disk, had any such corresponding effect upon the general structure of the crinoids as to entitle them to be considered characters of family importance, though in distinguishing subordinate groups they may possess some value. The radial and interradial plates are elements of far greater value.

2. Radial Plates.

In our nomenclature we have proposed different terms for special parts of the ray, discriminating between radials, brachials and arm plates. We designate as "radials" the whole succession of plates above the basals radially situated and enclosed within the body walls. The "arm plates" form the movable portion of the ray; the "brachials," while radials in position, are arm plates in construction, being free and distinctly articulated. The term "brachials" is therefore purely a conventional one, employed for greater convenience in description. We designate as "primary radials" those below the first bifurcation, while the "secondary radials" compose the first branches of each ray, the so-called "Distichalia" of Müller and other writers; and those of succeeding bifurcations are distinguished by referring them to the order in which they stand in succession. Müller, in applying the term "distichalia," was evidently not aware, that there are many fossil Crinoids in which these plates give off branches which likewise form a part of the test, otherwise he would not have regarded the arms as commencing at the "axillary distichals."

Schultze, in his Monograph Echinod. Eifl. Kalk, p. 5, improved upon Müller's views, and asserted that "the commencement of the arms begins invariably with the first distinct articulation of the ray." Like Müller, he uses the term "distichalia" for the secondary radials, and proposes no name to designate the plates of the higher branches within the body. Schultze differs from Müller in designating the free radials as arm plates, and in this he agrees with us; except that we distinguish those arm plates which are in direct vertical line with the radials as "brachials."

De Koninck and Lehon regarded the arms as beginning from the first bifurcation in the ray, no matter whether they became free at this point, or remained included within the body walls for some distance. They, however, characterized those plates which are immovably united with the calyx—the "distichalia" of Müller—as "pieces brachiales," and the movable joints as "articles brachiaux."

P. Herbert Carpenter, in his late work on the *Actinometra*, p. 22, states that the views of De Koninck upon the relation of these plates were unquestionably correct in the case of the "Articulate Crinoids," but that their application to the "fossil Tesselata" was beset with some difficulties.

We do not exactly coincide with any of these views. It seems to us that either the entire radial series of plates within the calyx, eventually up to the sixth division, or even higher, must be called radials, or this term must be restricted to the first radial plate. The first primary radials are the only plates, besides the basals, which form a part of the calyx *in all Crinoids*, and which can be homologized with the apical plates of other Echinoderms. All succeeding plates in the series are, in our own opinion, originally arm plates, which by growth during the life of the individual—chiefly, no doubt, in the embryo—and by development in geological time, were enclosed within the walls, and became thus modified into radials, the change being produced by growth and the development of additional interradials and interaxillary pieces. That this was the case in the higher orders of radials can be clearly demonstrated, and we feel confident, from analogy, that the same rule extends to the plates throughout the ray, which in turn suggests the idea that the arms fundamentally commence with the second radials, and not with the axillary plate as intimated by Carpenter, nor with the distichalia of Müller. In practice, however, and in this we agree with Carpenter, it is more convenient to regard the arms as commencing with the first free plate beyond the calyx.

The radials, as we designate them, consist throughout the Sphæroidocrinidæ, of five rows of plates, of two to three each, longitudinally arranged. The upper one bifurcates and supports upon its upper sloping sides two rows of one or more smaller plates—the secondary radials—which in turn, either support the arms directly, or divide again, and are followed by radials of the third order. In species of the latter kind, the upper plate in one or both divisions is axillary and supports on each sloping side another row of radials. The formation of higher orders of radials takes place in a similar manner, only one branch generally bifurcating, and one remaining single. In species with but two orders of radials the number of primary arms is limited to two in each ray, which, however, sometimes branch after they become free. Species with tertiary radials may have either three or four arms to the ray, depending upon whether one or both divisions bifurcate. Upon the same principle species with four orders of radials may have five to eight arms, and those with a fifth order may have from eight to twelve and even sixteen. The first number can only occur when all the branches remain simple; the latter when they all divide. Hence the number of primary arms is dependent upon the number of orders of radials represented in the species, and whether part of them bifurcate again or remain simple. It is important to note that simple arms are always given off from opposite sides alternately.

The number of arms is most frequently only of specific importance, but in cases where certain rays throughout a number of species are distinguished by a smaller or greater number, the arm formula may become almost a generic character, as for instance in *Batocrinus*, where the posterior rays are generally more developed. In *Eretmocrinus* the anterior and two posterior rays are less developed than the antero-lateral rays. In some genera the arms appear to be limited to a certain number, in others they vary. In the typical *Actinocrinus* there are species with four, five, six, seven and eight arms to the ray, but the normal number is uniform in the different rays. In all these cases, however, as well as not unfrequently within the limits of species, there are exceptions.

3. Interradials and Anals.

The interradial and anal plates occupy the intermediate spaces between the five radial divisions or rays in the body, and their number and shape depends altogether upon the number, position and proportions of the radial plates. They vary from a single plate to twenty or more, but are represented even in the young crinoid by at least one plate. In species in which the secondary radials of adjacent rays abut laterally, the number of interradials is naturally small, but when higher orders of radials are present, and especially when the rays are widely separated, the number is comparatively much larger. When the second and third radials are short, the number of interradials decreases, and it increases when they are long and narrow. This increase in number takes place by interpolation, contrary to the radials in which the increase is from the distal ends of the rays. The interradials are designed to fill up vacant spaces in the test, and this accounts to some extent for the great diversity which is found in their number within the limits of a genus, and within species at different stages of maturity. The first interradial is always larger than any of the rest, and is situated between the upper sloping margins of the adjoining first radials, except in some species of the Rhodocrinidæ in which it rests directly upon the basals, separating the ring completely. There are generally two plates in the second series, and two or three in each succeeding one, but in forms where the secondary or tertiary radials form an arch over the interradial spaces, as in *Batocrinus*, there is often only a single plate in the second or third series. The plates decrease in size upwards, those of the uppermost row being sometimes barely visible to the eye.

The posterior or anal area is readily recognized in most of the Sphæroidocrinidæ by its greater width, and by having a larger number, and a somewhat different arrangement of plates. In most of the genera the first anal plate is in line with the first radials, resting upon the basals. In our remarks upon the Cyathocrinidæ we noted the fact that in that family the anal plates, with a few exceptions, are directed toward the right side. In the Sphæroidocrinidæ, on the contrary, the symmetry is always bilateral, in some cases almost perfectly pentahedral, and a vertical section through the median line of the anal area, the anal aperture, the central dome plate, and along the anterior ray, divides the body invariably into two equal parts, and this symmetry, which extends to the arrangement of the arms, is one of the most characteristic features of the family.

The term "anal plates," as now used, designates the entire series of plates which compose the posterior interradius. Properly speaking, however, this is not quite correct. Careful examination shows clearly that the majority of these plates are in the true sense of the word "interradials," while only a few of them are actually "anals," by which we understand plates supporting the anus, or that can be accounted for as being in any way, directly or indirectly, connected with that organ. In the earlier genera, *Glyptocrinus*, *Reteocrinus*, *Glyptaster*, *Archæocrinus*, *Eucrinus*, and in all genera up to the Subcarboniferous in which the anal opening is lateral, the posterior area is distinctly divided into two equal parts by a single median row of plates. This row, which often extends to the anal opening, is composed of the true anal plates, but the plates on either side of it are interradials. By considering the latter, without regard to the median row, it will be found, that the two sections taken together correspond exactly in number and general arrangement with the interradials of the other areas, or at least differ not more than the other four differ among themselves. But it must be observed that in genera in which the first anal plate rests directly upon the basals (*Glyptaster*, *Eucrinus*, *Dorycrinus*, etc.), the first true interradial in the posterior area is divided, and is represented by two smaller plates, separated by a special anal plate (Pl. XIX, fig. 2). In these genera the anals proper extend from the basals to the anal aperture. *Glyptocrinus* and its congeners, in which there is no anal piece represented between the first radials and in which the first interradial range, consists of a single plate in all five spaces, the special anal plates begin with the second range in which there are three plates. In later geological times, when the anal opening became more central, the special anal plates decreased to two or three, and in the typical Actinocrinidæ in which we include the genera *Actinocrinus*, *Amphoracrinus*, *Strotocrinus*, *Physetocrinus* and *Steganocrinus*, they are reduced to a single plate.

Some of the Platycrinidæ have no special anal piece, and the posterior side differs merely by having a somewhat larger interradial, others however, as *Dichocrinus* and *Hexacrinus*, have a very large special plate. In some of the Rhodocrinidæ, like the Calyptocrinidæ, the symmetry of the calyx is almost regularly pentahedral, and none of the plates of the posterior side are actually anals.

4. INTERAXILLARY PLATES.

The space within the axil of the secondary radials is frequently filled by plates, for which we proposed in the first part of this work the name " axillary plates." This designation is undoutedly appropriate, but finding that it had been previously used by several authors for the bifurcating plates, we have thought best, in order to avoid confusion, to use the term "interaxillary" for these plates.

In the Platycrinidæ, which have rarely more than a single order of radials within the calyx, interaxillary plates are not represented. In the Actinocrinidæ and Rhodocrinidæ they may be present or absent in the same species, and sometimes in different rays of the same specimen, their number, like that of the interradials, increasing with age.

Roemer and Joh. Müller considered the presence of interaxillaries as of generic value, and the latter proposed a division of the genus *Actinocrinus*, placing all species having those plates under *Pyxidocrinus;* but it is evident that such a division is altogether artificial and not warranted by the facts, and if carried out would produce confusion.

5. VAULT.

One of the writers, in a paper upon "the internal and external structure of Paleozoic Crinoids" (Am. Jour. Sci., Sept. 1877), discussed the importance of the vault with reference to classification. It was noted that in a large number of genera, among them *Actinocrinus*, *Rhodocrinus* and *Platycrinus*, and their allies, the ventral covering is composed of strong plates closely cemented together, and that these form a free arch which braces the entire oral side of the body without the aid of oral plates. This is the general character of the vault in the family under consideration.

The vault in the Sphæroidocrinidæ is usually well preserved, owing to its solid structure, and is capable of accurate definition. Its plates vary from a few to many hundred; but, notwithstanding this diversity in number, their arrangement is governed by definite rules. Certain of these plates, which we have termed the "apical dome plates," are represented in every species of this group. They consist of a central piece, occupying a position directly above the oral centre, which in this family is quite uniformly the centre of the disk. It is surrounded by six proximal plates, interradial in position, of which four are large, and equal, and two smaller. The four large plates are placed above the four regular interradial spaces respectively; the two smaller plates which are equivalent to and take the place of one large plate, are directed posteriorly, being separated from each other by anal plates or the proboscis. These seven plates are easily recognized in species with comparatively few summit pieces and a lateral anal aperture (Pl. XVIII, figs. 7 and 9), but their identification is often difficult in forms in which a large subcentral anal tube is interposed between the two small plates, pushing them toward the anterior side, while the central piece rests against the side of the anal tube. (Pl. XVIII, fig. 8).

There are other vault pieces occupying a radial position which are either in contact with those just described, or, as is more frequently the case, separated from them by a belt of small pieces. Their number varies considerably among species, and depends upon the number of primary arms, without reference to the number of bifurcations after they become free. They increase in proportion to the number of primary arms, in the same manner and on the same principle as the plates of the calyx, each order of radials has its corresponding plates in the vault. Therefore, in adult specimens, with some practice the number of arms can be ascertained as well from the dome as from the calyx. In species with two arms to the ray, there are two ranges of corresponding radial plates in the dome ; the first or upper being a large bifurcating plate, equivalent to the primary radials of the calyx. This is followed by two other plates, which take the place of the secondary radials, one over each arm base, with a third plate—an interbrachial—between them.

When there are three arms to the ray, there are three ranges of radial dome plates, two plates in direct succession from the large bifurcating plate toward the single arm, and a second bifurcation, with one plate in each branch, toward the division with two arms. In species with four arms to the ray, there are two secondary bifurcations, producing radial dome plates of a third order, leading to each arm base, and so on. There are also interradial plates represented in the summit, occupying intermediate spaces between the radials, but their arrangement is very irregular and their number variable. In some genera the number of vault pieces is enormous, notably in *Strotocrinus*, which has a large number of arms. Looking at such a specimen with its vast number of apparently irregular vault pieces, one would scarcely expect to find this multitude of plates arranged upon a definite plan ; and this the same that prevails in the calyx.

We have called the principal plates in the vault apical dome plates, because they correspond to the apical plates of the aboral side. The six proximal plates surrounding the central piece represent the basals or genitals, and the radial dome plates, the radials or oculars. The centre piece may perhaps be compared with the underbasals, or the subanal plate of the Echini.

The apical dome plates, as the apical plates of the calyx, are fundamental elements, and are represented in the vault of all Sphæroidocrinidæ both in the young and the adult, from the Lower Silurian to the Subcarboniferous. They are generally larger than the other dome plates, and more prominent, frequently nodose or spiniferous, though in some species they cannot, at least in mature specimens, be readily distinguished from the other dome-plates which have attained equal size. In some genera, for instance, *Culicocrinus*, Müller, they occupy almost the entire ventral disk; in *Glyptocrinus* and *Rhodocrinus*, on the contrary, they fill only the median part. In some species of *Dorycrinus* the central piece is spiniferous and the radials nodose; in others, all these plates are spiniferous. In *Amphoracrinus* only the four larger proximal dome plates are nodose or spiniferous; in *Agaricocrinus* all apical plates are tuberculose; in *Batocrinus* the entire dome is composed of nodose plates. The proximal plates in some species are attached to the centre plate, in others separated from it by a ring of small accessory pieces, and in still others the centre piece is entirely isolated by the wide belt of minute pieces. The latter is frequently the case in large specimens, and in genera with but few primary arms, like *Megistocrinus*. In this genus it is interesting to find in very young specimens and in the smaller species the central and proximal plates in contact, while in the larger and adult specimens all are isolated, even the proximal plates being separated from each other. The radial dome plates are sometimes attached to the other apical plates, frequently so in young specimens, and generally in the Platycrinidæ.

In *Platycrinus* the radial series of the dome is composed of two rows of pieces alternately arranged, which decrease in size toward the arm bases, and of which the first and larger plate fits in the angle of two adjacent proximal plates.

The vault of the Platycrinidæ differs in several particulars from that of the other Sphæroidocrinidæ, and in these same characters it approaches the Cyathocrinidæ. We elsewhere suggest that the Platycrinoid is the simplest form of the Sphæroidocrinidæ, and that it represents the younger stage of the family. This is indicated by the construction of the calyx, but not less by the structure of the vault. In the genus *Coccocrinus* Müller, one of its earliest forms, the vault is composed of five large oral plates, resting upon the upper truncate side of a single interradial, and, as found in the fossil, it has a central oral opening and lateral grooves for the ambulacral furrows. Zittel has already noted the close resemblance of the above structure with the recent genus *Hyocrinus* Wyville Thomson, and the larval state of *Comatula*, calling it very appropriately " ein embryonales Stadium von Comatula in persistenter Form." The similiarity to *Hyocrinus* is probably merely superficial, as the lateral grooves in *Coccocrinus* were evidently closed by additional plates as in other Platycrinidæ, while they are open in *Hyocrinus.* The oral plates of *Coccocrinus* have been, by several authors, confounded with an apparently similar superstructure in *Symbathocrinus*, *Triacrinus* and other forms, but there is really no analogy between the two structures. The parts which enclose the opening at the oral centre in the latter forms are radial in position, and therefore not oral plates, but merely extended articulating facets of the radials. In those genera, the central space, like the opening at the centre of the oral plates, is also closed in perfect specimens by apical dome plates, which rest directly upon the extended processes. This group will be introduced hereafter as a separate family under the name Symbathocrinidæ.

The ventral disk in *Coccocrinus* bears a close resemblance to that of *Cyathocrinus*, but while the former has an additional interradial interposed between its radial and oral plates, in *Cyathocrinus* the intermediate plate is absent, and the oral plate rests against the incurved upper margins of the radials. In *Platycrinus* and similar genera, the two series of alternate plates which, as mentioned before, cover the radial regions of the dome, are interposed between three and sometimes five interradial plates, which in *Coccocrinus* as oral and interradial plates occupy the same position. This suggests the question whether these plates in the Platycrinidæ, and the interradial dome plates in the Sphæroidocrinidæ generally, are not the homologues of the oral plates, which are here broken up, and represented by several plates instead of one. This interpretation seems to us the more probable because *Coccocrinus* is one of the earliest known forms of the Platycrinidæ, and may be considered an embryonic type of the family. The homology in *Platycrinus*, however, extends only to the second or upper row of interradials, the first interradial, which exceptionally in this group is placed almost within the dome regions, is identical with the outer interradial plate of *Coccocrinus*, and as such forms part of the apical and not of the oral system.

This view differs somewhat from that expressed by us in Part I, p. 13, where we stated that the oral plate of the Cyathocrinidæ had "no representative in the vault of the Actinocrinidæ, at least not *externally;*" we were not at that time acquainted, with the genus *Coccocrinus*, which has given us new light upon the subject. We have thought heretofore that perhaps the triangular porous structures arranged around the inner test of many Actinocrinidæ, might be the homologues of the oral plates.

The vault throughout the Sphæroidocrinidæ is perforated with a single opening, which in all of them is more or less excentric; in some lateral and placed toward the periphery of the disk; in others sub-central leaning toward the posterior side of the body. The construction of the parts at the inner surface of the dome proves that the opening communicated with the posterior side of the visceral cavity, not with the digestive organs. It is separated from the ambulacral and oral systems by a strong partition attached to the inner surface of the vault, and hence the opening represents the anus, and is not the oral aperture, as has been supposed by the earlier writers.

The anus is either in the form of a simple opening through the vault, or is prolonged into a tube, which in *Batocrinus* sometimes attains a length of three times the height of the body including the arms. The tube is in all cases composed of heavy, generally nodose, wedge-form pieces, which are firmly put together, giving but little flexibility to the structure. It has no openings or pores through its plates or at the sutures, but has in the centre a comparatively small passage, with a minute outlet at the extremity. In cases where the anus is not extended into a tube, the aperture is generally situated within the centre of a wart-like inflation composed of very small pieces. It is possible that in such cases the small inner plates formed a little pliable tube, which could be drawn in by the animal like the anus in recents Crinoids,[1] but a contraction of the long solid tube of *Actinocrinus*, as has been suggested by Austin, is wholly impossible.

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[1] In the genus *Codonites* of the Blastoidea, we find in connection with the anal opening a similar little tube, which we found in one specimen extended outward, while in another, traces of its little plates are left within the opening.

There has been considerable difference of opinion as to whether species with a solid anal tube should be separated from those with a simple opening. Considering the slight distinctions upon which many of the genera have been founded, it would seem that the tubular structure ought to be of sufficient importance to justify a generic separation; but when we consider that various generic groups, after being carefully restricted with reference to all other characters, include both forms, its value as a full generic character must be somewhat doubtful. We once supposed that it might be a sexual difference, but the specific relations of the forms thus distinguished do not sustain that supposition. Both forms are not found in all the groups, though they exist in many, and throughout all divisions of this family. In some cases generic separations have been made upon this character, as for instance *Physetocrinus* has been divided from *Actinocrinus*, *Alloprosallocrinus* from *Agaricocrinus*, etc., while in other cases as *Platycrinus*, *Glyptocrinus* and *Strotocrinus* both forms have been retained in the same genus. It must also be observed, in this connection, that in some cases, especially species with a very slender proboscis like *Batocrinus rotundus*, we find occasionally specimens in which the tube seems to have been accidentally broken away during the life of the animal, and in which the fractured edges of its base had become absorbed and rounded, giving it the appearance of a naturally simple opening. That the simple opening could have been produced in a like manner in *Strotocrinus* and other genera, no one would for a moment suppose after examining good specimens.

The fact that the crinoid lived on without the tube, at least proves that this structure had no important influence upon the general organization of these animals.

A tube is more frequently found in genera in which the arms are arranged in a continuous series around the body, while in species with a simple lateral opening the arms are arranged more or less in clusters, leaving wide spaces between the rays. In the former case, the long tube could discharge the excrements free from the arms, and in the latter it was not needed as the refuse matter could be easily discharged between the bases of the arm clusters. In view of these facts, we think a subgeneric division sufficient to mark the two structures, but this should be done uniformly and we shall accordingly propose subgenera where necessary for this purpose.

The vault does not completely cover the calyx, but leaves along the line of junction a row of oval or circular passages which have been called arms or " ambulacral openings." The belt in which they occur is known as the "arm regions," and their distribution in the different rays is expressed by the " arm formula." Through the arm openings which are very conspicuous in the Sphæroidocrinidæ, food entered the body, and they served as passages for the ambulacral vessels. In a mature specimen the number of primary arms can be ascertained by counting the arm openings; but not always in young specimens, or in species in which the radial portions are extended into free rays.

By " free rays " we mean lateral extensions of the body, composed of a succession of radials, unconnected by interradials, and covered with similar plates, as solidly and in the same manner as the radial portions of the dome proper. These free rays, whether composed of only a few plates as in *Platycrinus*, or extended almost to the full length of the arms as in *Eucladocrinus* and *Steganocrinus*, are actually portions of the body, and the arms are given off from them in the same manner as from the body in other cases.

In the Platycrinidæ generally, there are within the calyx primary radials only, all the higher orders of radials being included within the free rays. In the body of a *Platycrinus* in its ordinary preservation, we find but five arm openings, but whenever the bifurcating plate is well preserved at its distal end, ten openings are visible,[1] and these form passages for the free rays which here divide, each branch giving off arms laterally and from opposite sides. The free rays are rarely preserved in the fossil unless the arms are attached, when they really appear like arms and have been described as such. That they are not arms is proved by the fact that their ventral side is not provided with a furrow, but is covered in the same way as the vault proper. In these forms, as might be expected, the number of arms cannot be determined from the arm openings, unless the full length of the ray is preserved; any fracture of the ray, whether cutting off one arm or a dozen, shows in the specimen only a single opening.

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[1] This proves that P. Herbert Carpenter is correct in saying that the division of the arms actually begins at the middle of the bifurcating plates, (on Actinometra, p. 22).

The Platycrinoid with its simple form, is similar in structure to the young Actinocrinoid, in which some portions of the ray are yet in the condition of free appendages. The young Actinocrinoid, at this stage, has the same number of arms as the adult; but in species with numerous arms, the upper divisions of the ray, which in the mature animal are incorporated in the body walls by means of interradial and interaxillary plates, form free appendages in the younger stage, and consequently the number of arms is comparatively less than in full grown individuals. In *Strotocrinus*, which has the greatest number of arms, we find in very young specimens only four arm openings to the ray; approaching maturity there are eight, afterwards twelve, and in fully matured individuals there are perhaps sixteen or more. Specimens in different stages of growth, have frequently been described as distinct species on account of variation in the number of arm openings; and this has even been extended to genera. As growth progressed, the upper branches gradually lost their free character by being absorbed into the body walls through the interpolation of interradials and interaxillaries, both in the calyx and in the vault. The plates which covered the ventral side of the free appendages were thus drawn into the vault, and became at length a part of the main body; but the Platycrinidæ, which have no interaxillaries nor increase of interradials, retain the free appendages during life.

As a general rule it may be asserted, that in the Sphæroidocrinidæ the plates of the vault increase in number outward in a similar manner to the plates of the calyx. The various plates of which the body is composed might be separated into two classes:

1. Plates which either do not increase in number, or do so only at the distal ends, and not by interpolation, including the basals, radials and arm plates.

2. Plates which increase by interpolation only, including the underbasals, interradials, anals and interaxillaries, to which we might add the joints of the column.

6. Arms and Pinnules.

The arms in the Sphæroidocrinidæ are either simple or branching, and are constructed either of a single or double series of joints. Single arm joints are restricted to the Silurian, all Devonian and Subcarboniferous genera have two rows of alternately arranged joints in the arms. In the Cyathocrinidæ, almost to the close of the Subcarboniferous, the arms are composed of single joints, but in the Kaskaskia Limestone and Coal Measures a few species occur with double-jointed arms, intermingled, however, with species apparently of the same genus, in which the arms are constructed of single wedge-form joints alternately arranged. These two structures run so closely into each other through transition forms, that we have been compelled to arrange them in some cases under the same genus, although we have in other cases considered the arm structure to be of generic importance. For this we have been criticised by Prof. Wetherby, of Cincinnati, who thinks it "a singular statement, that a character in forms of the same geological age may be generic in one case, and only specific in another." He evidently overlooks the fact that all Crinoids in their young stage have single-jointed arms, and that the double-jointed feature is a product of growth which primarily was only an individual variation, but which, by becoming fixed and constant in certain forms, attained generic value, especially when taken in connection with other characters. The best specific and generic and even family characters, originated in individual variation, and at some period in the paleontological history of the organism were without value as a means of classification. Near the close of the existence of the family Cyathocrinidæ, the double-jointed arm structure began to be developed, in some forms irregularly, in others to such a degree as to be constant, and to form a distinguishing characteristic of many species, which thus fell naturally into a generic group. This process is illustrated in *Eupachycrinus*, *Hydreionocrinus* and *Erisocrinus*, and there are similar examples among the Sphæroidocrinidæ. The young *Platycrinus* and *Actinocrinus* have a single series of cuneiform arm joints, which are constructed exactly like those of the adult *Poteriocrinus*, and the pinnules are given off in a like manner. At a more advanced stage the joints begin to enlarge laterally in such a manner that the sharp inner angles interlock. This process commences at the extremities of the arms, and gradually involves the lower portions down to the bases. During this stage we often find the lower arm joints quadrangular, with parallel sutures, followed by wedge-form and cuneiform pieces, and finally the tips constructed of a double series of plates.

The same development, which thus took place during the life of the individual, is observed to go on in geological times, but not contemporaneously in different families. In the Actinocrinidæ and Platycrinidæ it became complete in the Silurian, and is found invariably in all succeeding forms. In the Cyathocrinidæ, that structure appeared only at the close of the Subcarboniferous, shortly before the family became extinct. In this group, the arm pieces attained that marked wedge-form which everywhere preceded the double joints in the Burlington limestone, and here in some species of *Poteriocrinus* and *Cœliocrinus* the plates began to interlock already at the tips of the arms. This became more frequent and more conspicuous in the Kaskaskia group, where in some few cases, it extended to the entire arm.

The different stages of individual growth, as they became gradually introduced paleontologically and fixed, undoubtedly form excellent generic characters, but we must not forget that there was a time in the life of the crinoid at which the arms were neither single- nor double-jointed, but at which the joints began to interlock, and when probably a very few days brought about important changes in the arms of the growing animal. This stage is represented paleontologically among the Cyathocrinidæ by *Eupachycrinus*, *Erisocrinus* and *Hydreionocrinus*, and in this view of the case it is not difficult to understand how this arm structure may be of generic importance as a rule, but scarcely of specific value in exceptional cases.

It has been stated that the double-joint structure was introduced in the Sphæroidocrinidæ in the Silurian, and this occurred under exactly the same conditions as it did later on in the Cyathocrinidæ. By far the greater number of species in the *Lower* Silurian have single arm joints, and these, with a few exceptions, consist of quadrangular pieces with parallel sutures. In the *Upper* Silurian we find a few forms with single joints, and along with them arms with cuneiform joints—either interlocking or not—associated in the same strata with species having double series of arm plates, and we find all intermediate gradations between the two extremes.

In some of these species the two structures are found combined, in others so closely associated that it is next to impossible to separate them; and in still others the extremes are separately represented. Generic divisions based upon these variations, unless accompanied by other distinctive characters, seem to be unnecessary and inexpedient. It would require the creation of a large number of new genera, which would probably have to be subdivided to accommodate other transitional forms, and so on without end.

The double series of joints resulted from the increasing width and outward growth of the arm ; hence arm joints which originally were simple and cuneate did not in the mature animal extend through the full width of the arm, but gradually interlocked by their sharp angles, so that joints on each side, which at first were separated by another joint, came by degrees to be partly in contact and to rest upon each other. Therefore, in double-jointed arms every joint at each side bears a pinnule, while in those with single joints the pinnules are found only on alternate sides.

The arms in the Actinocrinidæ and Platycrinidæ divide rarely after they become free, the branching as a rule taking place in the body or in the free rays, *Megistocrinus*, *Amphoracrinus*, and *Periechocrinus* form the only exceptions. In the Rhodocrinidæ, on the contrary, the arms branch as a rule beyond the calyx.

The ventral grooves in the arms of this family are less deep, but comparatively wider than those of the Cyathocrinidæ. They are bordered on each side by a row of long pinnules, which cover them perfectly. Whether the grooves were closed by marginal plates seems to us doubtful, although Prof. Wetherby states that he has observed such plates in *Glyptocrinus*, they probably occur below the bifurcation where the arms should be regarded as free rays, or perhaps they are restricted to oral arms, such as P. Herbert Carpenter describes in *Actinometra*

The *pinnules* throughout this family are long, closely crowded together laterally, and the two rows with which each arm is provided fit together so neatly, and cover the arm furrow so perfectly, that additional plates were scarcely needed. Each pinnule is composed of a number of joints, which differ in form in different genera. In some they are of equal width and height, outwardly convex; in others higher than wide, with the outer surface flat ; in some they are entirely smooth, and in others provided with a peculiar hook; but in all cases they lie so close together side by side, that it appears as if the pinnules were laterally attached. In *Actinocrinus* and *Strotocrinus* each pinnule is furnished near the middle of its outer surface with a tooth-like spine which curves abruptly upwards; these spines are short and obtuse near the arms, but gradually increase in length toward the tips of the pinnules. As a rule the pinnules are deeply grooved on their inner surface, and in perfect specimens the grooves are covered by a double series of very minute pieces, though owing to defective preservation this covering is rarely observed. In young specimens, while the arms are composed of a single series of joints, the pinnules are not in contact, and are only given off from the alternate joints, but when the alternate arm joints meet by lateral growth, and the pinnules attain their full size they become gradually connected. D'Orbigny's genus *Edwardsocrinus* was founded upon a young *Platycrinus*, whose arms and pinnules were in their transition state.

7. INTERNAL CAVITY.

The construction of the interior of the body of all Paleozoic Crinoids is best known in the Sphæroidocrinidæ, among which, specimens preserving some parts of the delicate organs have occasionally been found.

The inner surface of the vault is often deeply grooved toward the brachial zone, producing corresponding elevations outwardly on the test. There are generally five large grooves, each branching into two smaller ones, the former corresponding to the five rays, the latter to their main divisions. This kind of vault is found most frequently among the Rhodocrinidæ. Among the Actinocrinidæ external ridges are rarely observed, but in their place the vault within is strengthened with bars or braces radiating from near, but not joining at the centre. The braces widen toward the arm bases, where they fold over to form regular tubes, corresponding with the natural grooves in the vault just described, and they branch as those do. In genera in which the rays are extended into free appendages, and in which but five ambulacral canals pass out from the vault proper (*Platycrinus*, *Steganocrinus*, etc.), the grooves are deep and in some cases were evidently closed and formed into tunnels, leaving, however, in either case beneath the median portion of the dome and in front of the anus, a space which is occupied by narrow grooves, meeting in the centre, and following the median line of the radial depressions and galleries below the vault to the arm openings.

In some specimens of Actinocrinidæ, almost the entire test is lined with a delicate calcareous plexus or network. This lining is not in contact with the test directly, but connected with it by small partitions, producing innumerable little chambers, which communicate with each other and with the visceral cavity. There is, at least, one such partition or support from each plate of the test, generally arising from the median portion of the plate. (Pl. XIX, fig. 16). The plexus is very delicate in some specimens, in others—mostly in large specimens—rather dense and rigid, but in all of them perforated with conspicuous pores or passages, whose arrangement corresponds with the direction of the sutures between the plates of the test. There is one pore at least to each angle of the plate, but sometimes additional ones in large individuals. The structure extends but little below the regions of the second radials, leaves passages at the arm openings, and toward the vault reaches to a place near the median portion of the ray, leaving at the centre an open space in the test which is occupied by the central vault piece. From this space five wide avenues, corresponding with the grooves on the inner surface of the vault, pass out toward the arm bases. The avenues produce five subtriangular interradial or interpalmar fields, which are raised conspicuously above the floor of the vault. They are of rather dense texture at the borders, the inner side somewhat thickened, while the surface of the median portions is rough and uneven, perforated with large and small passages which communicate with the avenues.

Four of the interpalmar fields are equal, the posterior one frequently larger and penetrated by the anal aperture. In species with a lateral opening all five fields have about the same form, and the central space between them is of pentangular outline. The case is different in species with a subcentral anus, when frequently the posterior field is larger and encroaches deeply upon the middle space, giving to it a lunate instead of a subcircular or pentangular outline. In species of this kind, the anus is placed near the edge of the interpalmar field, but separated from the central space by a partition which forms the border of the field. In species with secondary radials, the avenues divide, sending a branch to each arm, and forming thereby, between the interpalmar fields, a smaller intrapalmar[1] one similarly constructed.

A calcareous lining, such as described, has been observed by us with slight variations in *Batocrinus*, *Dorycrinus*, *Teleiocrinus*, (Meek and Worthen's Strotocrinus B), *Agaricocrinus* and *Eretmocrinus*, and probably existed in-many other genera. In the *Actinocrinites*, or typical Actinocrinidæ, the inner framework was either less developed, or was of a more perishable nature. In the genus *Actinocrinus* it is indicated on the inner floor of the test by little roughened places, which we take to be traces of the pillars which supported it. In *Physetocrinus* even these have not been observed, but it is a characteristic feature of that genus, that the plates of the calyx have along the sutures at each angle very distinct indentations resembling pores, which give to the outer surface of the test almost the appearance of the inner plexus in species of *Batocrinus* or *Dorycrinus*. Whether there was any communication with the visceral cavity through these indentations cannot be ascertained from the fossil. The test at these points is exceedingly thin and transparent, but we have never detected an actual passage. It must also be noted that the vault in that genus has similar indentations, but these, contrary to the others, open out from the inner floor of the test, being arranged along the radial grooves, not interradially as those along the calyx (Pl. XIX, figs. 5 and 16). In *Strotocrinus*, an internal framework has been observed in connection with the calyx, but none with the vault, and its typical form had apparently, like *Physetocrinus*, slight indentations along the inner floor of the vault.

The general internal structure indicates a concentration of organs toward a point beneath the centre of the vault, in front of the anus, but not to the anus itself. The latter is situated distinctly outside the radiation, *i. e.*, interradially. The grooves which we have noticed in the vault were figured by De Koninck and Lehon in their Recherches Crin. Carb. Belg., but they seem to have regarded them as muscular impressions. Billings, in the third and fourth Decades of the Canada Geological Report, was the first to treat of them in connection with the ambulacral system. He showed how impossible it was that the ambulacral canals in some Paleozoic Crinoids could be continued along the outer surface of the vault, and he reached the conclusion that they passed into the body at the arm bases. It is remarkable that Billings, after making this important discovery, in connection with which analogy suggested that the food entered the body in the same manner, clung as late as 1870 to the old theory that the subcentral passage in these crinoids—interradiately situated as we have shown—served both as mouth and vent. This view was advocated by him in a series of interesting articles, published 1869-70 in the Am. Jour. Science and Arts, Nos. 142, 145, 149, as "Notes on the Structure of Crinoidea, Cystidea and Blastoidea." Since that time, it has been most generally conceded that the interradial opening was the anus only, and that the oral centre or mouth in the earlier crinoids was hidden from view by external structures.[1] Billings' views with regard to the ambulacral passages were confirmed by Wachsmuth's discovery of radiating tubes beneath the vault,[2] which, as he ascertained, connect with the ambulacral furrows in the arms. We have since examined these tubes in several other specimens, both of *Actinocrinus* and *Strotocrinus*, and are enabled to give additional information regarding them.

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[1] The term "*inter*palmar Felder" was used by Joh. Müller for the "interradialen Felder zwischen den Tentakelrinnen im Perisom des Pentacrinus, '*Intra*palmar Felder' for the interdistichal Felder" (Monatsber. Berl. Acad. 1841, p. 218).

The *radiating tubes* are attached to the vault, running parallel to its inner surface. They consist of five main trunks, which follow the direction of the five main avenues which separate the interpalmar fields. They bifurcate in the same way and until a branch connects with every arm. They are composed of four rows of plates, two below and two above. The two latter touch with their edges the inner surface of the vault, are alternately arranged, and grooved along their median line, leaving a tunneled passage between the walls of the tube and the vault. The trunks of the two lateral sets of tubes on the same side not unfrequently meet before reaching the peristome, but the anterior ray is always distinctly separated.

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[1] The following writers have expressed this opinion: Schultze, 1866, Monog. Echin. Eifl. Kalk, p. 7; Meek and Worthen, 1869, Proc. Acad. Nat. Sci., Phila., p. 323; Lovén, on *Hypomene Sarsi*, reprinted Ann. and Mag. Nat. Hist., Sept., 1869; Wachsmuth, "On the Internal and External Structure of Paleozoic Crinoids," Am. Jour. Sci. and Arts, Aug. 1877, p. 115; Zittel, 1879, Handb. d. Palæontologie.

[2] Described by Meek and Worthen, Geol. Rep. Ill., vol. v, p. 329, and Wachsmuth, Am. Jour. Sci., Aug., 1877, p. 119.

Whenever tubular canals have been observed, they are preserved only to the border of the central space, but none of them have been found to join in the centre. In a specimen of *Actinocr. glans*, however, the tubes before terminating bend downward toward the visceral cavity, give forth lateral processes, as if disposed to branch, and expose two openings at the extremities directed to opposite sides. The openings indicate that the tubes may have been connected with each other by lateral passages, and formed a ring around the centre. This is evidently the structure of *Actinocr. Verneuilianus*, in which a circular vessel is observed beneath the centre at a short distance from the vault; no ambulacral tubes are attached to it, but there are small radial openings with which they might have been connected. The lower portion of the ring is composed of minute interlocking pieces, with five additional openings interradially situated. This ring is comparatively large, enclosing within its circumference the contracted upper part of the convoluted digestive organ, which is well preserved in the specimen from which these facts were obtained.

A tubular skeleton, as above described, has thus far been observed only in the Actinocrinidæ, but a tubular passage beneath the vault, in connection with the arm grooves and oral centre, has been traced in most groups of the Palæocrinoids, and no doubt existed also in the Blastoids. In *Cyathocrinus*, and probably in the Cyathocrinidæ generally, the tube is constructed of two series of pieces overlying the oral plates, and these again are covered by two similar series of plates, which form a part of the vault. In *Granatocrinus* the tubes follow the pseudambulacra, being covered by three series of small plates which must be considered extensions of the vault(Pl. XIX, fig. 3).

It is now generally conceded that the tubular canals beneath the vault contain the same organs which in modern crinoids are exposed on the ventral disk, and like them embrace the food passages, and certain other vessels in connection with the ambulacral system. In this view of the case, it is reasonable to further consider that the annular vessel, above described, served as a water-vascular ring.

The relations between the vault and the ventral covering of recent Crinoids are not so close as has been sometimes supposed, they are indeed different things, although there are certain analogies between some of their parts. Among these are the oral plates, which are represented in some of the later Crinoids, but absent again in the fully grown *Pentacrinus* and in the *Comatulidæ*. They are also absent in the Sphæroidocrinidæ, unless we consider the interradial vault pieces to be their representatives. We have already suggested that all interradial plates in the dome—exclusive of the proximal pieces—may perhaps have been modified oral plates which, either by division or interpolation, gradually increased in number. The dome of *Coccocrinus* has a single oral plate to each interradial field, while the corresponding spaces in most species of *Platycrinus* are occupied by three and occasionally five pieces each. It is as easy to consider the single plate of the former to be represented by three in *Platycrinus*, as that the three are sometimes replaced by five within the limits of the same genus, the plates occupy the same position in both cases, but in some groups the true orals meet laterally which is not the case with the interradial dome pieces of *Platycrinus* or *Actinocrinus*, nor with the undivided plates of *Coccocrinus*. In *Cyathocrinus* where the orals are very conspicuous, they join beneath the radial groove, and form the floor upon which the ambulacral tube rests. The bottom of the tube is composed of two series of pieces, which are covered directly by vault pieces in two alternate rows, whose lateral margins rest upon the upper edges of the two orals; while in *Platycrinus* the corresponding vault pieces abut laterally against the sides of the interradial—oral—plates in an unbroken succession. In *Platycrinus* the interradial plates thus take exactly the same position as the exposed part of the oral plates in *Cyathocrinus*, while the covered parts are unrepresented. In *Coccocrinus*, a covering of the ambulacral groove has not yet been observed, but judging from the fissure between the oral plates, it probably rested just upon their edges, and formed an intermediate link between the vault structure of the Cyathocrinidæ and Platycrinidæ.

In the Actinocrinidæ and Rhodocrinidæ, the alternate dome plates are not so readily distinguished, as in the Platycrinidæ and forms with free rays, in which they are well marked in the extended parts. In the recent Crinoids the alternate plates are represented by the "Saumplättchen," which, however, instead of forming a part of a solid vault, are movable, and line the lateral margins of the tentacle furrows.

The proximal and central dome plates are altogether unrepresented in recent Crinoids. This is best perceived by comparing *Coccocrinus* as usually preserved, with *Hyocrinus* or other recent genera in which the oral plates are developed. In both cases, there is at the oral centre an opening at which the grooves converge, surrounded by the oral plates; but, while in *Hyocrinus* and all recent genera this opening is unobstructed by solid parts, in *Coccocrinus*, *Cyathocrinus*, and the Palæocrinoids generally, it is covered by the apical dome plates. The central piece generally occupies the median portion of the vault, and always indicates the centre of the oral system.

We have already noted narrow grooves upon the inner surface of the vault, which meet on the central piece, and follow the median line of the radial depressions and galleries to the arm openings. Only three main grooves meet at the centre, those of the two lateral rays are uniting before reaching that point (Pl. XVIII, fig. 1). The grooves are best observed in natural casts of the interior, in which they appear on the surface in the form of narrow bands or ridges (Pl. XIX, figs. 5 and 9). The position of the grooves indicates that they may have contained axial cords in connection with a nervous system located beneath the central plate. The location of the nervous system within the regions of the ambulacral centre is in analogy to the structure of other Echinoderms, except the Comatulidæ, in which, according to P. Herbert Carpenter, the principal nervous systems are located at the apical side, and in connection with the quinquelocular organ which occupies the cavity of the centrodorsal plate.[1]

The interpalmar fields are composed of a soft skin, but although this is more or less incrusted with limestone particles, which sometimes almost look like vault pieces, they have no affinities with the plates of the vault. The plates of all recent Crinoids are perforated with numerous pores for the introduction of water into the body, a function which could not well be performed by the interradial pieces, but much less by the solid undivided oral plates of *Cyathocrinus* and *Coccocrinus*. In the Cyathocrinidæ, these functions may have been performed by the ventral sac which is profusely punctured, but evidently not by the simpler ventral tube of the Sphæroidocrinidæ which is destitute of such openings. Nor can we imagine that there was any such communication through the dome proper, its plates are perfectly connected at their sutures, and the interradial series especially are strengthened by strong braces within.

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[1] On some points in the anatomy of *Pentacrinus* and *Rhizocrinus*. Jour. Anat. and Phys., vol. xii. p. 35.

There are evidently closer relations between *Cyathocrinus* and *Hyocrinus* or genera with oral plates, than between the Pentacrinidæ and Sphæroidocrinidæ, in which those plates are either unrepresented or greatly modified. The latter two types form the extremes, and are probably more distant in their relations with each other, than most Blastoids and Cystideans from the Palæocrinoids.

The affinities of the Palæocrinoids with the Blastoids, become more apparent by our recent discovery of hydrospires in a specimen of *Teleiocrinus.* Their exact construction has not yet been fully ascertained, but that such organs existed in some of the Actinocrinidæ is now demonstrated beyond a doubt. The specimen is fragmentary, it was obtained from a narrow cherty band of the Upper Burlington Limestone, and is itself silicious. The interior is solid, with the exception of a natural concavity beneath the vault, at which point it was broken in quarrying, exposing a part of the upper face of the tubular skeleton. Portions of two tubes only are visible, and these are broken transversely after their second branching, the fracture giving a cross-section of the tubes and surrounding parts. In *Teleiocrinus* as in *Strotocrinus* proper, the lateral rim contains radiating tunnels formed by partitions between the divisions of the rays. The tunnels, as observed by us in several specimens, are divided transversely into two compartments, of which the upper one is occupied by the ambulacral tubes (Pl. XIX, figs. 7*b* and 8). In the specimen under consideration the lower or dorsal compartment has a semicircular outline, and within this, below one of the branches of the ambulacral tubes, there are visible two distinct folds, closely resembling the folds in the hydrospires of *Granatocrinus* (Pl. XIX, fig. 3). Beneath the adjoining branch, the folds cannot be so well distinguished, but the outlines of the hydrospires are also there faintly indicated. Considering that the arms in the Blastoids are inverted and recumbent, and that their calcareous portions represent not only he solid parts of the arms, but also a part of the test, it will be seen that the hydrospires above noted, and those of the Blastoids, have not only a similar form, but also a very similar position.[1]

The hydrospires of the Crinoids, like those of the Blastoids, are placed in close proximity to the arms with which they were probably in communication, close to the test and within the general cavity of the body.

The above is, to our knowledge, the only case in which hydrospires have been observed among the Sphæroidocrinidæ, but they were probably present in other genera, and perhaps in the Palæocrinoids generally; while these organs are unknown in all later and recent Crinoids, and in other groups of Echinoderms.

It is a fact worthy of note that all Cystideans and Blastoids, and so far as known, all Palæocrinoids which possess hydrospires had a subtegminal mouth, and a solid test built up of plates so closely fitted together that expansion or contraction was impossible. Expansion in some parts, however, was necessary to produce circulatory currents for the introduction of food. In most Echinoderms, including all recent Crinoids, this is accomplished by means of the pliant test and soft appendages which surrounded it. The Echini alone, like the Paleozoic Crinoids, have a rigid test, but they possess an external mouth, and in addition to their numerous soft appendages a movable actinal membrane, capable of considerable expansion, even in some cases beyond the line of the actinostome. It seems to us not unlikely that the hydrospires served the purpose of gills, producing by their contractions and dilatations the requisite circulation to introduce food and expel the refuse matter. This would account for their absence in the recent Crinoids and other Echinoderms, and would suggest that they were probably connected with numerous soft appendages along the arms, arranged perhaps in like manner as the pores along the ambulacra of the Blastoids, but not as in the Cystideans, in which the pores which connect with the hydrospires are distributed over different parts of the body. A better knowledge of these organs, as they exist among the three great divisions of the Paleozoic Crinoids, would doubtless afford far more satisfactory characters for separation than we now possess.

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[1] The vault in the Blastoids, as we understand it, consists not merely of the plates which cover the oral opening, but extends all along the median portions of the pseudambulacra (Pl. XIX, fig. 3), forming underneath a good-sized tunnel, which we take to be the homologue of the ambulacral tube of the Crinoids. If this interpretation is correct the structure bears the closest similarity to that found in those Crinoids in which the vault is extended into free rays, and in which these extensions combine to some degree the characters of the arms and body. The recumbent arms of the Blastoids are, according to this, lateral extensions of the body which take the place of true arms; but while in the Crinoids the radial extensions give off regular arms, in which the ambulacral tubes are converted into grooves, the corresponding parts in Blastoids remain attached to the body, and the pinnules form the only free appendages. It is possible, however, that in the Blastoids the lateral furrows which traverse the ambulacral fields were not covered by plates, and that these correspond to the open arm grooves—respectively arms—in Crinoids.

Dr. Hambach (Contributions on the Anatomy of the genus *Pentremites*, p. 7) is probably correct in supposing that the pinnules of the Blastoids were not connected with the pores, as hitherto believed. We think it probable that they rested in the funnel-shaped pits which alternate with the pores, and which communicate with the lateral grooves of the pseud·ambulacra, while the pores probably communicated with the hydrospires. This view coincides with what we have heretofore suggested, that the upper face of the pseudambulacra corresponds to the grooves within the arms of the Crinoids, and indicates that there are close affinities between the ambulacral field itself and the solid portion of the arms. The passage directly beneath the field is probably the dorsal or axial canal, which by the inverted position of the arms became the inner instead of the outer passage. The hydrospires in the Blastoids are placed beneath the canal, and extend along the perivisceral cavity of the body, like in the case of *Teleiocrinus*.

In the abdominal cavity of the Palæocrinoidea, the only structure which has been observed consists of a peculiar skeleton located beneath the tubular canals, which from its position, in analogy to other Echinoderms, has been referred to the digestive apparatus.[1]

In its usual preservation, it is a large convoluted body resembling the shell of a *Bulla*, open at both ends. The upper end is placed beneath the centre of the vault, and the lower directed toward the base. It is dilated above; contracted below; its surface about parallel with the walls of the visceral cavity. In some species it is subcylindrical, with the vertical axis the longer; in others globular or even depressed globose; but it is always truncate below, and never extends to the inner floor of the basal plates. The walls are coiled without touching at any point, and the convolutions are directed outward from left to right, varying in number from two to four in different species.

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[1] Meek and Worthen, Geol. Rep. Ill., v., p. 328, call it a convoluted support of the digestive sac. Wachsmuth, Am. Jour. Sci. Aug., 1878, p. 125, terms it the "alimentary canal."

In the usual state of preservation the walls are perfectly solid, almost like a " convoluted plate " as which it was described by Hall. In transverse sections, they are seen to be strong, and appear to be constructed of two partitions closely fitted together and united at the edges. The unusual thickness and apparent double nature of the walls in these specimens misled Wachsmuth in 1877, who considered the walls to be the body of the alimentary canal. This is evidently a mistake. We now know, from a number of other specimens, that the wall was simple in all cases, very delicate, and constructed of an extremely fine filigree work, which generally in the fossil became thickly incrusted with silicious matter on both sides, thus producing the apparent duplication of the wall. In good specimens, a magnifier shows the wall to be composed of an extremely fine network of minute pieces or bars, with intervening meshes. These bars, according to Meek and Worthen, " do not intersect each other at any uniform angle, but anastomose so as to impart a kind of irregular regularity to the form and size of the meshes."

That this network was in some way connected with the digestive organs, is no doubt true, but whether it formed a mere support for the digestive sac, as Meek and Worthen suggested, or was an extensive plexus of blood vessels surrounding the ambulacral canal, is a question we are as yet unable to solve. It should, however, receive a more appropriate name than any yet given, and we propose to call it the " œsophageal network," which may be changed when its special functions and affinities are discovered.

One of the writers found a specimen of *Actinocrinus*, in which the convolutions were nearly intact, and by removing the outer fold, the inner or upper end, as distinguished from the outer or terminal part, could be examined (Pl. XIX, fig. 12). The organ has the usual dense structure, and where it comes into view, is an elongate tube, which passing downward widens at first gradually to near the middle of the visceral cavity, then rapidly until it attains a width equal to two-thirds the entire length of the cavity. The upper part descending spirally turns from right to left, but on becoming wider the whorls are abruptly reversed, and thereafter the convolutions are from left to right. The outer end also tapers rapidly, assuming the form of a flattened tube, and ascends spirally on the outside, while the other end is directed toward the oral centre, but a connection with the food grooves has not yet been observed.

In all cases where the œsophageal network has been examined, among the Actinocrinidæ and Platycrinidæ, it varies only in outline and in the number of whorls; while in *Ollacrinus* the entire skeleton resembles a large spiral. In the only specimen observed, it apparently consisted of a large round canal, which turned spirally on its axis, and which near the basal plates turned upward, but the organ is in a fragmentary condition, and it is quite possible that this part was surrounded by other convolutions. Until recently this organ had been observed only in crinoids from the Burlington group. Angelin, however, in the Icononographia Crinoideorum Sueciæ, figures several examples from the Upper Silurian of Sweden (Pl. 26, figs. 12, 12 *a*, *b*,). It is well preserved in these specimens, and resembles that of later Actinocrinidæ. It differs, however, in being closed at the outer side, while the inner parts, as in Burlington specimens, are distinctly coiled. The outer wall is pentangular in outline, open toward the basal disk, and consists of a very delicate porous texture, appearing like an envelope for the inner or coiled parts, and as such possibly represents the perivisceral plexus, which in some cases almost equals the œsophageal network in delicacy of structure.

8. Column.

The column in the Sphæroidocrinidæ is generally circular transversely, though sometimes elliptical or pentagonal and even quadrangular. It is elliptical only in *Platycrinus*, and the pentagonal form occurs only in *Reteocrinus* and some few species of the *Glyptocrinites*. The central canal varies from large to extremely small, and is round or pentagonal. In *Platycrinus* it is so minute that in columns of an inch or more in thickness on their long diameters, the opening will scarcely admit the point of a needle. In the Rhodocrinidæ it is irregularly pentagonal, and as a rule small. Among the Actinocrinidæ also, the passage is generally not above medium size, but in *Megistocrinus* it is remarkably large throughout the column and all its branches.

By the earlier writers, new species were often based upon fragmentary columns, a practice which has fortunately been abandoned, since it became known that the different parts of the column in the same specimens are often widely dissimilar.

In the growing animal, new columnar joints were continually introduced by interpolation between the older segments, and these younger joints, which are found throughout the column in all stages of development, produce striking changes in the general aspect. The column matured from the root upward, and the upper part remained throughout the life of the crinoid in a kind of immature state, wherein the intercalated joints did not attain the width of the others. The uppermost joints, however, although they were probably among some of the earliest developed parts of the column, are not separated by smaller joints. Gradually, sometimes between the third and fourth joints, new plates make their appearance; the first one so thin as to be scarcely visible, the next which lies between the succeeding joints much larger, the third probably reaching full size. Secondary intercalations follow between the new pieces, the intervening spaces between the larger joints increasing gradually to a maximum, from which point down the column seems to be mature, for all succeeding spaces have a like number of intercalated joints. As a general rule, the column decreases somewhat in thickness from the calyx for a certain distance down, after which it increases again towards the root. In some species the primary joints are only longer, but not of greater diameter than the others. This is the case in *Platycrinus* where the new joints seem to have been formed directly beneath the calyx, their number increasing in length gradually along the stem, and not in sections as in the Actinocrinidæ and the Rhodocrinidæ.

Lateral cirrhi along the column have been rarely observed, and in this family probably existed only toward the root. The form of the root is exceedingly variable, and depended evidently upon the conditions of its place of attachment. When living in a soft or sandy soil, it seems to have been provided with a great number of small rootlets which are given off both vertically and horizontally; but when it was attached to a rock or other hard substance, the lower surface grew entirely flat and was often deeply grooved. The grooves pass out from the root, and apparently took the place of the vertical rootlets. The central passage extends to the smallest rootlets and is often of considerable size. We have already noted this fact in Part I, and suggested that probably the rootlets may have had respiratory functions by introducing water into the body.

In adult specimens of Actinocrinidæ and Rhodocrinidæ the column was long. We have never seen its full length, but have in several instances traced it three to four feet without seeing either root or body, and we suppose that it was in some genera very much longer.

Of *Platycrinus*, however, we have examined five complete specimens measuring from the tips of the arms to the extreme ends of the fine rootlets from 7 to 27 inches—the latter in a large species. In all these specimens, the column gives off for some distance large lateral branches, which decrease in size toward the end of the root, each one with irregular branches which divide again and terminate in hair-like tubes. We never saw a *Platycrinus* in which the root was flattened, as in some of the Actinocrinidæ, and it seems possible that the crinoids of this genus only grew on a soft bottom, or possibly floated about with their column like an anchor. The same was evidently the case in the genus *Glyptocrinus*, in which the column was short, tapering to almost a needle's point, without lateral branches.

9. MODE OF GROWTH AND PALÆONTOLOGICAL DEVELOPMENT.

In the Pentacrinoid larva of *Antedon*, the calyx is composed chiefly of very distinct, rather large basals, alternating with which are five dots, which represent minute radials. The crinoid at this stage consists only of five columnar joints, the large basals, the rudimentary radials, and of five large oral plates which cover the entire peristome. The succeeding radials, at first unrepresented, develop afterwards, and the arms make their appearance at a much later period.

Of the Palæocrinoids, the first stages are, of course, unknown, all the specimens we have discovered—even the very youngest—being already provided with arms, and hence were considerably advanced in the scale of growth. It can be ascertained, however, by a comparison of larger and smaller specimens, that their mode of growth must have been similar to that of *Antedon*. In the smaller, and as we consider them, younger specimens, the basals, compared with the other plates, are much larger, being almost the same size as in mature individuals. Next in size are the first radials, which are larger than the second and third. In the interradial series the first plate is much the largest, and the number of interradial and anal plates is considerably less in young specimens than in the adult, thus indicating that the calyx in these crinoids was developed from the basals up, as in their living representatives.

With the development of the first interradial, apparently simultaneous with the second and third radials, the Platycrinoid form, the simplest of the Sphæroidocrinidæ was complete. The earliest types of the Platycrinidæ known to us, but evidently not the earliest representatives of that group, are from the Upper Silurian. In *Coccocrinus* the body is composed of three basals, two by five radials—the first very much the larger—a single interradial, and five large oral plates, exactly as we must expect from analogy to find the Actinocrinoid in its earlier phases. The rays in the Platycrinoid are free from the primary radials up, but the first joints of the two main divisions are simple and constructed similar to the radials in the body of the Actinocrinidæ. To transform the Platycrinoid into an Actinocrinoid, it only requires the interpolation of one or more interradial pieces between the proximal plates of the first division of the ray. By this simple process, the plates which were before free in the Platycrinoid, were incorporated into the body, and raised to the dignity of secondary radials.

Many of the earlier Rhodocrinidæ and Actinocrinidæ are characterized by highly elevated ridges, which extend all along the radial series of the body. They run vertically along the middle of the primary radials, divide upon the third plate, and branch to the secondary and tertiary radials, whence they pass very gradually into the arms. The ridges are very prominent, rounded exteriorly, and as they approach the arm bases, assume nearly the shape and size of the arms. The plates upon which they are extended, in their upper series, scarcely differ in length from the first free arm plates, and all gradually diminish upward. The longitudinal ridges are evidently not accidental, nor a mere ornamentation, but represent the arm joints as they were when first developed in the young animal. In this early stage they were round joints, the lateral wing-like extensions being developed afterward, when by reason of the upward growth of interradial and interaxillary pieces, the plates became parts of the body. We find on the surface of many internal casts of forms belonging to this group similar but narrow ridges, which follow the same direction as those upon the test. The ridges in these cases are evidently the impressions of rudimentary grooves, indicating that the plates at that stage were provided with ambulacral furrows like regular arm plates. They also had pinnules attached, which like the arm plates were by the growth of the animal absorbed into the calyx. The fixed pinnules, which Wetherby describes in *Glyptocrinus Richardsoni*, Cincinnati Soc. Nat. Hist., 1880, and which we found also in *Gl. decadactylus* and *Reteocrinus O'Nealli*, confirms our views as to the mode of growth of the Palæocrinoid, and throws light upon the palæontological development of Crinoids generally.

The number of secondary radials varies considerably with age. In *Reteocrinus O'Nealli* we have observed as many as seven, but the number may be even more in some cases; and on the other hand we found in some younger specimens only three or four. The first and second of these plates, and the third and fourth seem to have been united by syzygies, at least the first and third bear no pinnules, while beyond the fourth pinnules are given off regularly from alternate sides as in the free arms. The proximal pinnule is given off toward the outer side of the ray, or, which is the same thing, toward the interradial area, the next one toward the interaxillary space. The plate which gives rise to the first pinnule has almost the form of a bifurcating plate, but instead of supporting radials of a higher order, it bears on its inner sloping side a third secondary radial, and on the outer a stout pinnule. The first fixed pinnule is highly elevated above all other plates of the interradial space, is rounded like the radials, and almost as conspicuous. In one of our specimens it consists of five plates, three of which are soldered into the body, and the fourth apparently free. The fixed plates are nearly as strong as the radials and may be easily taken for them, having like them winged extensions by which they are laterally connected with the interradial plates. The upper joint is much smaller and constructed like the joints of the free pinnules. The second pinnule has only two joints in the body, the third but one, which in either case are larger than any of the free joints, but which already attain somewhat more the aspect of regular pinnules, and are given off in a similar manner. In a specimen of *Glyptocrinus Richardsoni*, kindly loaned to us by Prof. Wetherby, the first fixed pinnule is given off from the second plate above the first bifurcation, and consists of seven plates within the body, the third and fourth plates were joined by syzygies. The second pinnule, with but four joints within the body, springs from the opposite side of the fourth plate. The fifth plate, instead of a pinnule, supports a regular arm, and the sixth again a pinnule, but from the same side as the preceding pinnule. This is important as it suggests the idea that the pinnule may have here developed into an arm. That a transformation of this kind took place in some groups, is more than probable, as will be shown presently. In *Glyptocrinus decadactylus* only the second and third secondary radials are joined by syzygies, all succeeding pinnules being given off regularly.

The number of arms has been considered of specific importance among the Palæocrinidæ, and even genera have been based upon this character. The greatest variation in the arm formula is found among species of the typical Actinocrinidæ, in which we include, besides the genus *Actinocrinus*, also *Strotocrinus*, *Teleiocrinus*, *Physetocrinus* and *Steganocrinus*. These genera agree in the style of their ornamentation, and in the construction of the anal area, which differs somewhat from that of all other Actinocrinidæ. It is to be noted that in this group the specimens have, as a rule, the same number of arms in the different rays, the few exceptions being due to deficient or abnormal development of these parts.

The genus *Actinocrinus* has been very appropriately separated by Meek and Worthen into two sections, The one, with *Actinocrinus proboscidialis* Hall, as a type, has the arm-bases arranged in a continuous series all round; the other, with *Actinocr. multiradiatus* as type, has the rays formed into more or less protuberant lobes.

A. proboscidialis of the first section, which represents the simplest form of this interesting group, has only four arms to the ray. The first departure is *A. reticulatus* with four arms in all but the two posterior rays, which have five; the fifth arm where it exists, being placed below the line of the others and appearing somewhat crowded. Next in order are *A. limabrachiatus* and *A. clarus* with five arms, in which one of the divisions in each ray divides again. *A. sexarmatus* and *A. opusculus* have six arms or three to each division of the ray. *A. multibrachiatus* and *A. penicillus* have probably six, seven or eight arms, without regularity as to arrangement or distribution. *A. cœlatus* and *A. spinotentaculus* have a greater number than any other species of this section, having normally eight arms to each ray.

On examining a large collection of the different species, it will be found that a separation according to the number of arms is not so satisfactory as might be expected, for only a few specimens will be found—except the four-armed ones—which agree with the given arm formula of the species. The majority will be found to have in one or more rays very irregularly, either a surplus or a deficiency of arms, and the greater the number of arms a species possesses, the oftener such irregularities occur. The difficulty of identifying these species is further increased by the similarity—we might almost call it identity—of general form and ornamentation, which prevails throughout the group.

The gradual increase of arms would naturally lead us to inquire whether it might be connected with the growth of these crinoids—an idea which seemed at first plausible, inasmuch as the above species are found exclusively in the Lower Burlington beds ; but an examination of specimens, with the arms in place, shows that such is not the case. Specimens with four arm openings in the body to each ray, have also four simple arms, while they should have, if representing a younger stage of the six- or eight-armed species, the same number of arms as the adult, with the bifurcations taking place beyond the body as in *Platycrinus*. The fact is, however, that the arms of *A. proboscidialis* are not only simple, but from the base up, are composed of a double series of pieces, while the plates which should form the higher orders of radials in the adult are entirely absent.

In *Strotocrinus*, which is closely related to *Actinocrinus*, the variations in the number of arms are still greater, being among the different species from eight to twenty-four to the ray. *Strotocrinus* has also been divided by Meek and Worthen into two sections; the first including species with a simple anal opening directly through the vault, which they call the typical form, and the second, those with a large sub-central anal tube, for which we have proposed the sub-genus *Teleiocrinus*. The ornamentation among the different species of the two sections is remarkably similar, only that in some species the striations are more prominent, in others the nodes. The most important feature of the genus is the peculiar rim, which extends out horizontally from the body, formed of the higher orders of radials, which are connected by interradial, interaxillary, and some other apparently accessory pieces. In the allied *Actinocrinus spinotentaculus* with eight arms to the ray, the *Strotocrinus* rim is already indicated, and in specimens in which the arms are preserved, their lower portions stand out horizontally as in that genus; but the plates of these parts are not connected laterally, which feature, aside from the difference in the number of arms, constitutes the principal distinction between *Actinocrinus* and *Teleiocrinus.*

Throughout this group, all bifurcations of the ray—after the first—take place on the first plate in each order, only one of the branches dividing again, and this alternately from opposite sides, the other branch remaining simple. The arrangement is such that the bifurcating plates of each primary division of the ray follow each other in direct succession, forming two main trunks, while the plates which remain simple, and are succeeded by others to the edge of the rim, are given off alternately like pinnules. These lateral branches are separated from the main rays by small pieces, and each branch supports a free arm at the edge of the rim. Within the rim, the radial series are conspicuously marked by sharp carinæ or ridges, which pass from plate to plate, and follow both main and lateral divisions, while the small accessory pieces, which connect them, are formed into deep depressions. Comparing the ridges with the elevations we have described in *Glyptocrinus*, and which are found in other Silurian genera, the resemblance is indeed very striking. The ridges in the latter extend over the primary, secondary, and sometimes over the tertiary radials, and pass gradually into arms; but while we find in *Glyptocrinus* very strong arm-like pinnules, there are in *Strotocrinus* and *Teleiocrinus* pinnule-like arms, both included within the body walls, and both springing off laterally like ordinary pinnules. The lateral branches in the rim of *Strotocrinus* were evidently pinnules in the young animal, and free as in the younger stage of *Glyptocrinus*, but with growth gradually developed into regular arms; while those of the latter remained as pinnules during lifetime. This explanation accords with the construction of pinnules, which is so similar to that of arms, that it is in many cases exceedingly difficult to draw a line between them. In *Melocrinus* the alternate pinnule-bearing appendages were called by some authors arms, by others pinnules. The branches in *Cyathocrinus* were called pinnules by Wyville Thomson, and arms by most other authors.

Following out the observations, it seems probable that all arms above the first bifurcation are metamorphosed pinnules, given off from the primary radials. Applying this rule to the case of *Actinocrinus* and *Teleiocrinus*, the idea is suggested that *A. proboscidialis*, which is the most common species of the group, and has only four arms to the ray, is in all probability the progenitor of all similar Burlington species, evidently of both genera. In *A. recticulatus* only the proximal pinnule toward the posterior side was transformed; in *A. clarus* one pinnule in each ray; in species with six arms the first pinnule on the opposite side was added; in species with seven arms the first and second pinnules of one side, and the first of the other, and so on alternately on opposite sides. Although the increase of arms is frequently attended with some irregularity, the number of arms should here be considered of specific importance, and deviations from the normal number as intermediate steps between the species.

During the Lower Burlington Limestone epoch, the number of arms never exceeded eight to the ray, but in species even of that number the arms are so crowded together, that they could not have been arranged side by side, were not their lower portions bent outward, in the same direction as we find the rim in *Strotocrinus*. In species of *Actinocrinus* with only a few arms, the arms are movable from the base up; movement is less free in species with six arms to the ray, and the facility of motion is lessened with every increase of arms. This lack of mobility, of course, only extended to the lower arm joints, which for some distance were so closely crowded together that they could not have moved in any direction, and it was probably in consequence of this inactivity that the proximal arm pieces, which in the simpler forms were free, became gradually connected by growth. This was evidently the first step in the direction of *Teleiocrinus*. Afterwards, by still further increase of arms, additional plates became laterally attached, and in this way the rim was gradually developed. In *Actinocrinus* the rim was merely indicated by the adhesions of a few plates to the calyx, the primary rays, and their main divisions being still distinctly separate. In *Actinocrinus* (*Strotocrinus*) *serratus*[1] Meek and Worthen, which forms a kind of connecting link between *Actinocrinus* and *Teleiocrinus*, only the two main divisions of the rays were laterally connected, but the rim is not continuous above the five primary divisions of the ray.

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[1] This is the only species from the Lower Burlington beds which might be referred to *Teleiocrinus*.

We have already noticed the presence of small plates interpolated between the radial portions of the rim, forming sunken areas, and having altogether the appearance of accessory pieces (Pl. XVIII, fig. 1, *fp.*). A closer examination, however, shows a marked regularity in their arrangement, and there can be little doubt that they represent pinnules, given off alternately from opposite sides, and soldered into the body walls together with arm joints. This interpretation is confirmed by the allied genus *Steganocrinus*, in which the corresponding parts, under more favorable conditions, instead of forming a rim, remained free (Pl. XVIII, fig. 3).

Steganocrinus Meek and Worthen is connected with the other section of *Actinocrinus*—type of *A. multiradiatus*—in the same manner as the *A proboscidialis* group with *Teleiocrinus*. In *A. multiradiatus* and allied species, the third primary radial is bent abruptly outward, its upper articulating faces which support the higher radials being directed almost horizontally, thereby forming the rays into protuberant lobes, separated by wide and deep interradial depressions; contrary to *A. proboscidialis*, in which the arms are more or less continuous, and the sides of the calyx nearly straight up to the tertiary radials. We should have separated the two sections upon these characters, at least subgenerically, if Miller, in establishing the genus *Actinocrinus*, had not unfortunately chosen for the type a species which is intermediate between the two, thus rendering it difficult to determine the typical form. It is very evident that the structure of the rays of *A. multiradiatus* did not admit the development of a rim like that of *Strotocrinus* and *Teleiocrinus*, as even the most profuse growth could not well have filled the break between the rays, and the spaces between the arms within the ray were amply sufficient to afford them free motion. This we think furnishes a reason why, under similar conditions, the arms and pinnules of this genus, contrary to those of *Teleiocrinus*, remained free during life. *Steganocrinus* and *Teleiocrinus* have very close affinities in their structure. In both of them there are five main rays—a succession of radials longitudinally arranged—which give off arms alternately and from opposite sides; but, while in *Steganocrinus* the plates of the different order of radials are extended into free appendages, with free arms and free pinnules, the radials in *Teleiocrinus* and their branches and pinnules, to a certain height, are laterally connected and included within the body walls.

Strotocrinus bears the same relation to *Physetocrinus* as *Actinocrinus* to *Teleiocrinus*, *Physetocrinus* differs from the *A. proboscidialis* form, mainly in having a simple anal opening through the vault, instead of a tube, and the same character separates *Strotocrinus* from *Teleiocrinus*.

In *Eucladocrinus* of the Platycrinidæ, the case is the same as in *Steganocrinus*. In that genus an indefinite number of radials, apparently intersected by syzygies, are formed into long radial appendages, which give off pinnule-bearing arms from opposite sides. It agrees exactly with *Platycrinus* in the construction of the body, and both have free lateral appendages, in which the arms originate alternately on opposite sides. The arms of *Platycrinus*, however, are only given off close to the body, while those of *Eucladocrinus*, as in *Steganocrinus*, are given off continuously and the free rays extend almost to the height of the arms (Pl. XVIII, fig. 7).

Not less interesting is the case of *Melocrinus*, which we take to be a successor of *Mariacrinus* (as amended by us). Both genera make their appearance in the Upper Silurian, but, while the former does not survive later than the Silurian, the latter flourishes in greatest profusion in the Devonian. *Mariacrinus*, in its simplest form, has but four arms to the ray, two of which are given off like pinnules from the body toward the interradial spaces, while the two inner ones stand erect, are parallel and lie close together. In other species of the genus, the inner arms give off from one to three additional arms, always directed to the outer side of the ray. The arms are composed of single joints, which bear pinnules in the usual way. The two median arms of the ray, which in *Mariacrinus* are placed side by side, are connected in *Melocrinus* by a suture, and appear as a single arm composed of two series of plates, but the suture between them is straight, and the opposite plates are scarcely ever alternately arranged. That a coalescence of two arms actually took place here, is best demonstrated by the fact, that in the calyx the two parts are not only separate, but often have interaxillary pieces between them, and that each one has a distinct passage. The compound arms of *Melocrinus* give off at regular intervals, instead of pinnules, lateral arms, which are composed of a double instead of single series of joints, and bear pinnules. The difference from *Mariacrinus* thus actually consists only in the much greater number of lateral arms, and their being composed of a double series of plates. The increase of arms evidently took place under the same conditions as in *Steganocrinus* and *Eucladocrinus*, the modifications in the arm structure, due originally to individual growth, becoming fixed as generic characters, and following a general rule, by which it seems that the arms in all genera of the Sphæroidocrinidæ, on passing into the Devonian, change from single to double joints.

Let us now consider some cases of *Batocrinus* in which an increase of arms took place in the species under somewhat different conditions. It has been shown by us (Proc. Acad. Nat. Sci. Phila., 1878, p. 230) that *Batocrinus Chrysti*, as a rule, has two arms from each arm opening, differing thus from other species of that genus. In the *Actinocrinites*, and many other of the Sphæroidocrinidæ, the arm openings are mere breaks in the body, and the proximal arm joints consist of single plates, while in *Batocrinus* they appear more like passages penetrating the test, and the arms from their very base up are constructed of two series of pieces. We have in our collections several specimens, which in every other respect resemble *B. Chrysti* except that they have single arms. They were obtained exclusively from the lower strata of the Upper Burlington Limestone, the typical form of the species occurring in greatest abundance in the upper layers. The specimens with double arms are generally larger than the others, but we find them also very small, thereby indicating that the modified arm structure had passed beyond the stage of mere individual variation due to growth, and became a permanent character of specific value perhaps. *B. Chrysti* and its variety with single arms—for which we propose the name *B. Lovei*—have twenty arm openings, but at the same time only twenty so called respiratory pores, which are located, as usually in species with twenty arms, above the interradial and interaxillary areas. In both species the pores are placed at like distances from the arm openings, which seems to prove that the additional arm was given off from the opposite side alternately from the pores. The arm starts from the first free arm piece, which is changed into a bifurcating plate, but without materially increasing its size. Toward the close of the Burlington Limestone *B. Chrysti* underwent some changes, and the variety thus produced has been described by Meek and Worthen as *B. trochiscus.* It has a more spreading disk, a more concave dome, a comparatively lower body, is of larger size, and consequently has more interradials, but otherwise is not different from *B. Chrysti.* *B. planodiscus* Hall, which occurs still higher in the Burlington and Keokuk transition beds, and in the lower part of the Keokuk Limestone, is evidently a more mature form of *B. Chrysti* and *B. trochiscus*, which by enormous development in the radial regions, and a great increase of interradial and interaxillary plates, attained a still greater expansion of the disk. In *B. Chrysti* and *B. Lovei*, interaxillary plates are wanting; they are occasionally represented by one or two plates in *B. trochiscus*, while *B. planodiscus* has from nine to eleven, with a similar increase of interradials. In the latter species, the small bifurcating arm pieces, from which in *B. Chrysti* the second arms are given off, and also the two succeeding rows of pieces, in both arms, are enclosed within the body walls, the inner row as radials, the other as interradial or interaxillary pieces, which all attain the form and size of the associated plates in the lower orders. *B. planodiscus* has forty arms like *B. Chrysti* and *B. trochiscus*, but they are simple, branching in the body; while the other two species have twenty arms which branch in their free state. The increase of arms no doubt takes place in this group in a similar manner as in *Actinocrinus* and *Strotocrinus*, but while in the two latter, the alternate pinnules of only the two *main divisions* of the ray became arms, in *B. planodiscus* the proximal pinnule of each arm was thus transformed.

In *B. Chrysti* and its allied forms, we find an illustration of the difficulty we often encounter in discriminating between species and varieties. There are apparently four forms represented in that type, of which the two extremes, viewed separately, are well defined specifically as well as geologically, but placed in connection with the two others, they form a series which might well be taken for variations of one species.

A similar case is presented by a series of specimens obtained from the Keokuk Limestone of Indiana. The collection comprises nearly two hundred specimens of *Batocrinus*. but contains comparatively few species. By far the greater number came from Bono, Lawrence County, others from Edwardsville, Floyd County, a few from Canton, and the rest from Crawfordsville. The Bono and Edwardsville crinoids, in their general habitus, resemble Burlington fossils, but we have so far not been able to identify a single Burlington species among them, while we found several identical with species from Crawfordsville, though generally smaller. The crinoidal fauna of Canton includes both Bono and Crawfordsville forms, but embraces also some of the huge forms so characteristic of the Upper Keokuk beds of Keokuk, Iowa, and Nashville, Tenn., and which are entirely wanting at Crawfordsville and Bono. We have not been able to ascertain the exact relative age of each stratum, but are inclined to believe that the Crawfordsville bed occupies an intermediate position between those of Bono and Canton on one side, and Keokuk on the other.

The crinoids to which we allude are easily separated into two groups. Those of the first have flat, somewhat spatulate arms, a subconical or subturbinate calyx, and a variable arm formula, and are appropriately referred to the genus *Eretmocrinus*, while those of the second, which we refer to *Batocrinus*, have a globose body, round arms, with arm formula: $\begin{array}{c}4\ 4\\ \hline 4\ 4\\ \hline 2\end{array}$, rarely $\begin{array}{c}4\ 4\\ \hline 4\ 4\\ \hline 4\end{array}$.

Among thirty-two specimens of the first group, all from Bono, there are twelve which have sixteen simple arms: $\begin{array}{c}3\ 3\\ \hline 4\ 4\\ \hline 2\end{array}$, two others have at one side of the right posterior ray *a pair* of arms instead of a single arm—the formula may be graphically represented thus: $\begin{array}{c}1\ 1\ 1\cdot 1\ 1\ 2\\ \hline 1\ 1\ 1\ 1\cdot 1\ 1\ 1\ 1\\ \hline 1\ 1\end{array}$—, and in one specimen we find one of the anterior arms represented by a pair, while all the others are simple. The last three specimens no doubt are abnormal cases, but they are interesting as showing a tendency of the species to an increase of arms in the postero-lateral and anterior rays. All the above specimens can be safely referred to a new species which we call *Eretmocrinus originarius.*

There are thirteen other specimens, for which we propose the name *Eretmocrinus intermedius*, which agree with the former in all essential points, having the same peculiar ornamentation, the same form and size, and being derived from the same layers; but they differ in having, as a rule, in the anterior ray two, and in both postero-lateral rays three additional arms, while the antero-lateral rays are unchanged. The additional arms are given off alternately from the two main divisions of the rays as in Actinocrinus. They are simple and in most cases included within the body walls, except in the two posterior rays, in which the arms arising from the last bifurcation are arranged in pairs.

In this lot of crinoids there are two more specimens, one having twenty-one arms distributed thus: $\frac{1\,1\,2\ 1\,1\,1}{\underset{2\,2}{\underline{1\,1\,1\,1\ 1\,1\,2\,2}}}$, and the other twenty-seven, thus: $\frac{2\,2\,1,2\,2\,2}{\underset{2\,2}{\underline{2\,2\,1\,2\ 1\,1\,1\,2}}}$. Both agree with the two preceding species except in the arm formula, but even this is fundamentally identical with *E. originarius*, the simple arms of the latter being in part replaced by pairs. None of our Bono specimens have the double arm structure throughout all the rays, but we obtained from Edwardsville and Canton several specimens in which that feature prevails, and for which we propose the name *Eretmocrinus adultus*. The two irregular Bono specimens may not be the intermediate forms between that species and *E. originarius*, but this is probable, and they show how the double arm structure became introduced.

Scarcely less interesting are some specimens of *Batocrinus*. Among sixteen examples of a form which we call *B. Whitei*—eleven from Bono, two from Canton, and three from Edwardsville—there are fourteen with the arm formula: $\frac{4\,4}{\underset{2}{\underline{4\,4}}}$, while two of them have four arms to the posterior ray. No double arm structure has been observed in this species at Bono, but its apparent representative at Crawfordsville has always two arms from each opening. *B. Indianensis* has the same form and ornamentation as *B. Whitei*, and the same arm formula—with substitution of double for single arms—and it evidently bears the same relation to that species as *B. Chrysti* to *B. Lovei*, and *E. adultus* to *E. originarius*.

It would be interesting to pursue this line of examination further, and trace the relations subsisting among other groups similarly connected. But we have perhaps gone far enough to serve our present purpose. It is to be observed, however, that the importance of this kind of investigation, in its bearing upon systematic classification, can scarcely be overestimated. It has to do with the principles which lie at the very bottom, and it is only by the study of these relations, of the exact anatomical changes which produced individual variation, and in time permanent modification of forms, that we can hope to arrive at a correct understanding of the groups in nature, or be able to make scientific discrimination of families, genera, species and varieties.

Many species have been made, upon mere differences of growth; some upon unimportant variations in the arm formula; some upon abnormal development in certain parts of the body; others upon slight modifications in ornamentation; while still others were founded upon material so imperfect that neither figure nor description sufficiently defines the form. Our literature is so overburdened with synonyms that we fear a very large percentage of so-called species ought to be eliminated. We have undertaken to point out such cases among the Burlington and Keokuk Crinoids, and although we have been obliged to throw out a considerable number of species, we have only done so where necessity seemed to require it, and we suspect we should not have gone amiss by reducing the list still more. Schultze undertook the same task for the Crinoids of the Eifel, and, although we cannot agree with him in retiring certain genera, we concur in his determination of synonymic species. There are no doubt, also many synonyms among the Subcarboniferous Crinoids of Belgium and England. One of us had an opportunity, several years ago, of studying the original collection of De Koninck in the Museum of Cambridge, and became convinced that the eleven Belgian species of *Actinocrinus*, described in the Recherches Crin. Carb. Belg., might be safely reduced to four or five.

10. The so-called "Respiratory Pores."

In the first part of this work, on page 11, we called attention to certain pores, located in the body at the arm regions, on either side of the ambulacral openings, and we endeavored to show that they correspond in position with the so-called ovarian openings of the Blastoids. At that time we asserted that the pores were in some genera fixed at a definite number, independent of the number of arms in the species; that *Batocrinus*, for instance, had always twenty pores, whether the species had twenty arms or more, and that one-half the pores were located radially and the rest interradially. In this we were evidently in error; the pores probably always agree in number with the arms, and are really neither radial nor interradial, but are placed at the base of the arms. A specimen of *Batocrinus subæqualis*, now before us, with twenty-two arm openings, has twenty-two pores, and a specimen with twenty-four arms has twenty-four pores. In the former the vault became accidentally detached from the calyx, in such a manner, that we were enabled to follow up in both parts the direction of the pores as they pass into the body (Pl. XIX, fig. 4). Neither the pores nor the arm openings penetrate the plates, but both are placed between the sutures and appear as grooves situated within the upper series of radials. The grooves in the calyx are opposed by similar grooves in the corresponding parts of the dome, and pores as well as arm openings enter the body horizontally. The grooves which constitute the arm openings follow the median course, while the smaller grooves, forming the pores, enter obliquely from the sides, and join the others at—or just before—the point where they enter the general cavity of the body. The pores which are given off toward the outer arms of the ray are deeper than the rest, and connect with the arm openings at the moment these enter the general cavity. Those of the inner arms meet midway in the test, and in case there is another arm between the two divisions of the ray, its pores join the arm passages close to the outer surface of the test. This explains the fact that the partition between the two last-mentioned openings is so rarely preserved, and that these openings are generally found united in the fossil. The arrangement of the pores is similar in other genera of the Actinocrinidæ, the pores between the main divisions of the ray being universally more conspicuous than the inner ones. In the Platycrinidæ and other genera in which the upper radials are extended into free rays, the pores are located at the base of the arms, not at the base of the free ray, and hence are rarely observed. *Ollacrinus*, so far, is the only genus in which, in connection with the pores, appendages have been observed. They there form heavy, arm-like extensions, often surpassing the arms in length, with a channel through their centre. The channels unite with the arm passages within the test in a similar manner as the pores in *Batocrinus*.

The affinities which are apparent between the pores of the Actinocrinidæ and the ovarian openings of the Blastoids with regard to their position, suggests a probable analogy in their functions, and if the latter served as a madreporic apparatus it would seem reasonable to suppose that the pores in the Actinocrinidæ did the same. But there are objections to this, and another interpretation is at least possible. From what is now known of the ontogeny of the Palæozoic crinoids, we are inclined to think that the pores may have been originally pinnules, which with progressing growth were soldered into the body. This would explain the fact that all pores located beside the inner arms are located closer to the arm openings than those of the outer arms, for they are pinnules of higher branches in the body, and hence were less deeply enclosed in the test.

It would be interesting to trace the pores in genera like *Glyptocrinus*, in which the fixed pinnules retain their forms after they became fixed; but in those genera the arms are unfortunately located at the edge of the ventral disk, and an examination is difficult. In all carboniferous Crinoids in which the pores are clearly seen, no fixed pinnules can be traced externally in the test, and apparently no free pinnules were attached to the pores, or they should have been found preserved in some of our specimens.

The proximal pinnules in the recent Crinoids contain the genital glands, and it is at least not impossible that the pores as rudimentary pinnules, served as genital organs. This supposition is strengthened by a comparison with the ovarian openings of the Ophiuridæ and Astrophytidæ, which apparently occupy a very similar position to the pores of the Actinocrinidæ. Those, we believe, are said to be in part respiratory and so it is possible that the pores of these Crinoids had both functions.

As a convenient summing up of our discussion of the Sphæroidocrinidæ, we give the following

Condensed Family Diagnosis.

Body comparatively large, globular, conical or biturbinate; plates solidly cemented together, immovable, separated only by sutures; symmetry bilateral, sometimes almost perfectly pentahedral.

Calyx composed of basals, radials, interradials and sometimes interaxillary plates. Underbasals present or absent. Radials in at least two orders, the upper one frequently extended into free rays. Posterior or anal area wider than the four interradial areas, and the arrangement of its plates generally distinct. Ventral disk more or less elevated, constructed of numerous plates forming a free arch, unsupported by oral plates. The plates of the vault are arranged substantially upon the same plan as those of the calyx, and consist of the same elements. Apical dome plates well defined. Anus in form of a simple opening directly through the vault, or prolonged into a solid tube, perforated at the distal end, but without respiratory pores.

Arms composed of one or two series of pieces. Pinnules long, slender, generally in contact laterally. Food grooves and ambu-

lacral vessels entering the body through openings in the test, whence they are continued beneath the vault by means of tubes.

Digestive apparatus composed of a convoluted sac, surrounded by a delicate calcareous network.

Column long; its cross-section circular, elliptical, sometimes pentagonal or quadrangular; central perforation small to medium, rarely large.

A. Sub-family **PLATYCRINIDÆ** Roemer.

(Amend. Wachs. & Spr.)

The name Platycrinidæ has been used by most writers in a full family sense, and in this they seemed to be justified, as most of the genera are by their general aspect readily distinguished from those of the Actinocrinidæ and Rhodocrinidæ. The differences, however, which produce that particular habitus, are evidently not the result of marked anatomical modifications.

The body of the Platycrinidæ, according to the views of other writers, is composed only of basals, primary radials, and vault pieces, all succeeding plates in a radial direction are considered by them to be arm plates. The rays in this group generally become free from the first axillary, but the extended parts are true extensions of the body, covered like this by regular vault pieces, and these arranged in the same manner, they are not arms in our sense, as they possessed no true articulation. If the respective parts in the Actinocrinidæ are to be regarded as radials, then also are those of the Platycrinidæ, they compose in the former the sides of the body walls only in adult specimens, in the younger state they form free appendages as in the mature Platycrinidæ. The plates of the extended parts are joined by suture, there is no hinge line, and the articulation was by ligament only, probably similar to that of the anal tube, which certainly was flexible to some extent.

The distinctions between Platycrinidæ and Actinocrinidæ are more readily perceived than described, and seem to be fairly expressed by saying that the former represent a younger stage of the latter, and remained as a persistent type of that stage of growth. The interradial regions are represented by a single plate, leaving the upper radials unconnected laterally as in the young Actinocrinoid.

A close comparison of the three sub-divisions of the Palæocrinoidea shows that the modifications which each undergoes, sometimes in the same geological epoch, are more or less repeated in all of them. This is particularly the case as to the construction of the arms. The same development from single to double arm joints occurs in all of them, and simultaneously in the Upper Silurian. A similar analogy is found in the arrangement of the arms. In each group there are simple and branching arms, arms which are given off directly from the body, or laterally from free rays, and even the pinnules are arranged in a like manner. The plates of the body are composed essentially of the same elements, but in the Platycrinidæ comparatively few plates are enclosed within the calyx, many of them, which in the Actinocrinidæ form a conspicuous part of the body, being here found in the lateral appendages. In the Platycrinidæ, the calyx proper is constructed almost exclusively of basals and first radials, all higher orders of radials either forming a part of the brachial appendages, or, when partially incorporated with the calyx, being insignificant compared with the other parts. In this respect they exhibit a marked difference from the Actinocrinidæ and Rhodocrinidæ, in which the higher radials are prominent elements in the calyx. In the Platycrinidæ, the interradial plate is pushed into a line between calyx and dome, and appears like a dome plate, though being in fact a part of the aboral side, and analogous with the first interradial in the Actinocrinidæ, like this it rests upon the upper edges of the two adjoining first radials, which are generally notched for its reception, a position very different from that of the interradial dome plates. In *Dichocrinus* the radials are not notched, and the plate in question is actually pushed into the dome, but here also, as in all similar cases, a more profuse development of second and third radials within the calyx, would place this plate in position with the interradials in the Actinocrinidæ.

We have stated in our family diagnosis that the Sphæroidocrinidæ have at least one interradial plate; *Pterotocrinus* seems to be an exception to this rule, but in that genus the family relations are otherwise so clearly expressed, that it seems to us unnecessary to separate it on account of the absence of that plate. *Pterotocrinus* is the last survivor, and probably the most mature and extravagant form of the family In its typical species there are not only secondary, but also tertiary radials enclosed in the calyx, and the plates of the different rays meet laterally in the body. The case is similar to that of *Strotocrinus;* the arms, as in that genus, are crowded together, naturally producing at first a lack of mobility in the proximal parts of the rays, until eventually the sides became attached. In *P. crassus* and *P. Chesterensis* Meek and Worthen, in which the lower arm portions are comparatively narrower, the connection between the rays is not perfect, especially at the posterior side; while in *P. depressus* Lyon, and in all of Wetherby's species, the connection between the upper radial is uninterrupted, and the arms are given off directly from the body, and not from brachial appendages or free rays. In Meek and Worthen's species, in which the first radial plate extends to the top of the calyx, it is apparent that the first plate above, though pushed into the dome, is the analogue of the regular interradial plate of the group, but in *P. depressus*, in which that plate rests above the tertiary radials, it is probable that the interradial plate proper was pushed inwards, and either became obsolete, or is perhaps visible only at the inner side of the test.

The construction of the dome has been already so fully discussed that a few general remarks here will suffice. The vault resembles fundamentally that of the Actinocrinidæ and Rhodocrinidæ. The plates are comparatively large, and the apical dome plates very conspicuous. The radial regions are each composed of two rows of plates alternately arranged, which commence either close to the centre plate, or near the edge of the disk, and branch toward the free rays, following their direction, and paving their ventral surface. The interradial regions of the dome are comparatively large, composed of one, two or more plates. Anus in form of a small tube, or simple vault opening. Column round or elliptic, never pentagonal; perforation very small.

For greater convenience we have divided the Platycrinidæ into two sections:

A. **Platycrinites**, including genera with a marked pentahedral symmetry, and without special anal plates in the calyx.

B. **Hexacrinites**, with a decided bilateral symmetry, and a large anal plate enclosed within the calyx.

The presence of a special anal plate, upon which this division has been based, is somewhat remarkable, on account of the great size of the plate, and the comparatively large space which it occupies in the body; but too much importance should not be attached to it, as we find in the Actinocrinidæ and Rhodocrinidæ the same variation, and apparently without any disturbance of the relations between the genera. The presence of this plate in the Platycrinidæ is entirely in harmony with our idea that this group represents a younger stage of the Actinocrinidæ, for this anal plate was early developed in the animal, and is found in the youngest individuals in both groups of equal size with the first radial.

In 1843, the two Austins proposed (Monogr. Rec. and Foss. Crinoids) the name Platycrinidæ as a family designation, embracing the genera *Platycrinus*, *Cyathocrinus* and *Caryocrinus*, without special diagnosis, merely mentioning that those genera "had but few plates below the ray, and thus might conveniently be arranged into a natural group." They placed *Marsupiocrinus* along with *Crotalocrinus* under the "Marsupiocrinoidea."

Not any better is the arrangement of D'Orbigny, who placed *Platycrinus* under "Melocrinidæ," and *Edwardsocrinus* and *Dichocrinus* under the Cyathocrinidæ.

F. Roemer's "Platycrinidæ" (1855. Leth. Geognostica, Ausg. III, p. 228), agree substantially with ours. He brought into the family: *Platycrinus*, *Dichocrinus*, *Hexacrinus*, *Culicocrinus* and *Marsupiocrinus*, but unfortunately added *Atocrinus*[1] and *Symbathocrinus*, the first of which we place under the Cyathocrinidæ, and the latter we consider the type of a new family. Pictét (Traité de Palèont., 1857) made his *Platycriniens* a sub-division of the *Cyathocrinidæ* and enumerates under it the genera *Platycrinus*, *Edwardsocrinus*,[2] *Amblacrinus*,[3] *Marsupiocrinus*, *Atocrinus*, *Symbathocrinus* and *Adelocrinus*,[4] but placed *Coccocrinus* and *Haplocrinus* under the *Haplocrinidæ*, following Roemer.

The arrangement of Zittel (Handb. der Palæontologie) agrees with that of Roemer, except that he separates *Symbathocrinus* and adds *Cordylocrinus* and *Pterotocrinus* which had been established later. He also placed here *Storthingocrinus* which we propose to transfer to the Symbathocrinidæ.

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[1] *Atocrinus* McCoy, is evidently a *Cyathocrinus* in which the sutures between the plates are invisible, owing to the condition of the fossil, and not a *Platycrinus* as supposed by some authors. The plates of the body and the arms agree exactly with *Cyathocrinus*, while no *Platycrinus* of the Subcarboniferous has single arm joints.

[2] Syn. of *Platycrinus*.

[3] D'Orbigny, insufficiently defined, probably syn. of *Coccocrinus*.

[4] Phill., insufficiently defined.

The Platycrinidæ are first met with in the Upper Silurian, whence they range to the close of the Subcarboniferous.

We arrange the two sections as follows :—

a. PLATYCRINITES.

1. *Coccocrinus.*
2. *Cordylocrinus.*
3. *Culicocrinus.*
4. *Marsupiocrinus.*
5. *Platycrinus.*
   Subgenus *Eucladocrinus.*
6. *Cotyledonocrinus.*

b. HEXACRINITES.

7. *Hexacrinus.*
8. *Dichocrinus.*
9. *Talarocrinus.*
10. *Pterotocrinus.*

a. PLATYCRINITES.

1. **COCCOCRINUS** Joh. Müller.

1855. Müller. Verh. Naturh. Verein Rheinl., xii, p. 20.
1860. F. Roemer. Foss. Fauna. Westlich. Tenn., p. 51.
1879. Zittel. Handb. d. Palæont., i, p. 347.
Syn. *Platycrinus* Roemer, 1844 (not Miller), Rhein. Uebergangsgeb., p. 63.

Müller proposed the genus *Coccocrinus* for a species which had previously been referred by Roemer to *Platycrinus*. The two genera are identical in the construction of the calyx, and the summit really forms the only distinction between them. In well-preserved specimens of *Coccocrinus*, the vault is constructed of five large oral plates, which rest upon five interradial pieces. The oral plates are not in contact laterally, but leave five slits, which in the fossil have no floor nor covering, and leave an open space in the centre. It is evident that the central space and open furrows were covered in the animal as in similar genera, and this suggests a closer analogy with *Platycrinus* than had been suspected by Müller, Schultze, Zittel or Carpenter, who suggested an unobstructed mouth. The interradial plate which rests upon the edge of the first radials is characteristic of both genera, and the two or more succeeding interradial dome pieces of *Platycrinus* are possibly analogous with the single so-called oral plates of *Coccocrinus*. This, if correct, would reduce the generic difference to that of a compound oral plate in *Platycrinus*, as against a simple one in *Coccocrinus.*

Zittel has arranged this genus with *Haplocrinus* under a separate family.

Generic Diagnosis.—Body small, globose; calyx constructed like that of *Platycrinus;* vault composed of five oral plates, resting upon five smaller interradial pieces.

Basals three; two of them equal, the third smaller by half, the suture between the two equal plates directed toward the right posterior ray; the two sutures in connection with the smaller one directed to the anterior and left lateral rays, thereby disturbing the general symmetry of the calyx, which otherwise would be perfect.

Radials 2 × 5; the first large, quadrangular, its upper corners slightly truncate for the reception of the interradial, and its upper side slightly convex. Second radials narrower by half than the first, and very short; they are almost quadrangular—although bifurcating plates—on account of the very obtuse angle upon which they support the arms.

Arms unknown, only a single joint having been discovered, which is small and round.

Interradials, one to each area resting upon the corners of the first, and between the second radials; its upper part truncate, deflected towards the summit, and supporting another somewhat larger plate, giving five in the vault, which form a low pyramid. The latter, which are oral plates, do not join laterally, nor in the centre, but leave a median space and lateral slits, which, in perfect specimens, were doubtless closed, the one by the apical dome plates and the slits by small marginal pieces. Posterior side only distinguished by the anal opening, which is placed within the suture of the interradial and oral plate.

Column small, cylindrical; central canal round and narrow.

Coccocrinus differs from *Haplocrinus* in having the first radials simple instead of compound, and in the oral plates, which in the latter are formed into compartments for the reception of the arms. It differs from *Platycrinus* and *Cordylocrinus* in the summit structure, and from the former also in having the column round instead of elliptical and twisted.

Geological Position, etc.—Of the two species referred to this genus, one is from the Lower Silurian of Tennessee, the other from the Devonian of the Eifel, Germany.

1844. **Coccocr. rosaceus** F. Roemer. (**Platycr. rosaceus**) Rhein. Uebergangsgeb., p. 63, Pl. 3, fig. 3; Müller, 1855. **Coccocr. rosaceus**, type of the genus. Verh. Naturh. Verein Rheinl., xii, p. 21, Pl. 7, figs. 5 a, b, c Bronn, 1860. Klassen des Thierreichs, ii, Pl. 28, figs. 8 a, b, c; Schultze, 1867. Echinod. Eifl. Kalk., p. 89, Pl. 12, fig. 13. Devonian, Eifel., Germany.

1860. **Coccocrinus bacca** F. Roemer. Silur. Faun. West. Tenn., p. 51, Pl. 4, figs. 5 a, b, c. Niagara Gr., Tennessee.

2. CORDYLOCRINUS Angelin.

1878. Angelin. Icon. Crin. Suec., p. 3.
1879. Zittel. Handb. der Palæontologie, i, p. 365.
Syn. *Platycrinus* Hall (not Miller), Pal. N. Y., iii, p. 113.

Hall (Pal. New York, iii) describes three species under *Platycrinus* which evidently belong to *Cordylocrinus*. They have the same number of radials, and the arms are similarly composed of a single row of joints. The genus should, however, be amended so as to admit species with branching arms. We propose the following:

Generic Diagnosis.—Body small, closely resembling a young *Platycrinus.*

Basals three; unequal, closely anchylosed. Radials 3 × 5: the first very large; the second quadrangular, much wider than high, resting within the concave upper margin of the first; the third, which has the proportions of the second, but bifurcating, supports the two primary arms of which each ray is composed.

Arms simple or branching, composed of single joints. Pinnules long.

Interradials, one between the upper edges of the first radials, and followed by three or more similar plates in the dome, the number of the latter being greater on the posterior side.

Form of dome and anus, and condition of the apical dome plates unknown.

Column cylindrical, joints alternating in size, the larger giving off sometimes at intervals long lateral cirrhi.

Geological Position, etc.—Restricted to the Upper Silurian, both in Europe and America.

We place here the following species:—

1878. **Cordylocrinus comtus,** Angelin. Type of the genus. Iconog. Crin. Suec., p. 3, Pl. 23, fig. 3. Upper Silurian. Gothland, Sweden.

*1861. **Cordylocrinus parvus,** Hall. (**Platycr. parvus**). Pal. New York, iii, p. 114, Pl. 4, figs. 6, 7, 8, 9. Lower Helderberg. Herkimer Co., New York.

*1861. **Cordylocr. plumosus,** Hall. (**Platycr. plumosus.**) Pal. New York, iii, p. 113, Pl. 4, figs 1-5. Lower Helderberg. Herkimer Co., New York.

*1861. **Cordylocr. ramulosus,** Hall. (**Platycr. ramulosus.** Pal. New York, iii, p. 115, Pl. 4, figs. 10-13. Lower Helderberg. Herkimer Co., New York.

3. CULICOCRINUS Joh. Müller.

1855. Joh. Müller. Verh. Naturh. Verein Rheinl. xii, p. 23.
1855. F. Roemer. Lethæa Geogn. Ausgabe iii, p. 243.
1879. Zittel. Handb. der Palæont., i, p. 367.
Syn. *Platycrinus* Wirtgen and Zeiler, 1855. Verh. Naturh. Verein, p. 15.

Müller proposed *Culicocrinus* merely as a subgenus of *Platycrinus*, a distinction which seems to us scarcely in proportion to the differences apparent between the two forms, and we therefore propose it as a genus. Zittel even places it with *Briarocrinus* under a separate family. *Protoeryale confluentina*, Roemer (Verh. Naturh. Vereins, xii, p. 29, Pl. 9, figs. 2, 3), is according to Müller probably identical with *Culicocr. nodosus.*

Generic Diagnosis.—Body elongate; calyx higher than wide; basals and first radials heavy and nodose; symmetry almost perfectly pentahedral.

Basals three, large; two of them equal, pentagonal, the third smaller by half and quadrangular; sutures very distinct. They form a pentagon, the central part excavated for the reception of the column; separated from the radials by a deep groove. Primary radials 3 × 5; the first large, tuberculous, quadrangular in outline but in fact hexagonal, owing to the slight truncation of the upper corners adjoining the interradials; the second about quadrangular, narrower than the first, very short, and three or four times wider than high; the third varying in form and size, but generally triangular. The latter plates mostly occupy only the median portion of the margin of the second radials, in which case the outer ends of those plates aid in supporting the secondary radials; sometimes, however, they fill the entire width of the second primaries, and the secondary plates rest wholly upon the sloping sides of the triangular pieces. Secondary radials 1 × 10, generally wider than high, supporting two arms to the ray.

Arms stout, attached laterally up to the second or third joints, above which at some distance they branch. They are from the base up composed of two rows of joints, alternately arranged, and meeting by zigzag sutures.

Interradials: one, placed between the upper corners of the first radials, higher than wide, narrowing toward the summit, extending to the top of the secondary radials, and abutting against the proximal dome plates. The plate at the posterior area is somewhat wider, and supports the anal aperture which is almost lateral.

The dome, according to Müller, is composed of only five plates, but we suggest that probably his largest plate includes four plates, the spiniferous central vault piece, the two proximal vault pieces, and a small anal plate between them. The four large proximal vault pieces, each crowned with a spine, are no doubt, correctly represented. Those few plates occupy the greater part of the summit, leaving but little space for the radial dome plates, which as yet are unknown.

Column round.

Culicocrinus, in its form and general habitus, has the closest resemblance to our genus *Talarocrinus*, which bears the same relation to *Dichocrinus* as *Culicocrinus* to *Platycrinus*. In *Platycrinus* and *Dichocrinus*, all radials above the first plate form a part of the free rays, while in the two other genera all the primary and even the secondary radials are included in the calyx. This genus further differs from *Platycrinus* in having three primary radials, a character which distinguishes it also from *Marsupiocrinus*, the construction of the vault being likewise very distinct. It differs from *Cordylocrinus* in the arm structure.

Geological Position, etc.—The only known species is from the Lower Devonian of Germany.

1855. **Culicocrinus nodosus** Wirtgen and Zeiler. (**Platycr. nodosus.**) Verh. Naturh. Verein, xii, p. 15, Pl. 6, figs. 2, 3. Müller, 1855. **Culicocr. nodosus.** Ibid., p. 24, Pl.. 8, figs. 1–4. Grauwacke. Near Coblentz, Germany.

This species is known only by impressions left in the rock, and casts taken therefrom.

4. **MARSUPIOCRINUS** Phillips.

(Not **Marsupiocrinites** Blainville = **Marsupites** Mant.,
nor **Marsupiocrinites** Hall. = **Lyriocrinus**).

1839. Phillips apud Murchison, Silur. System., p. 672.
1842. Austin. Ann. Mag. Nat. Hist., x, p. 109.
1843. Austin. Ibid., xi, p. 198.
1857. Pictet. Traité de Paléont., iv, p. 332.
1878. Angelin. Icon. Crin. Suec., p. 2.

1879. Zittel. Handb. der Palæont., p. 365.
Syn. *Platycrinus* F. Roemer, 1860. Silur. Faun. W. Tenn., p. 35.
" *Cupellæcrinus* Troost, 1850. List. Crin. Tenn., p. 61; also Shumard, 1866. Catal. Pal. Foss. North Amer., p. 361.

Marsupiocrinus has undoubtedly close affinities with *Platycrinus*, with which it has been identified by Joh. Müller and Hall, but it differs in the higher orders of radials, which, instead of being extended into free rays, form a part of the calyx; and also in having the column round instead of elliptic, and the canal larger.

Troost's genus *Cupellæcrinus*, which was defined as late as 1866 by Shumard, must be considered a synonym of this genus, unless it should hereafter be found that the anus in the former consists of a simple opening through the vault, and not a tube as in the latter, in which case a subgeneric division might be justified. Troost, in his List. Crin. Tenn., mentions several species under *Cupellæcrinus*, one of which is probably identical with Roemer's *Pl. Tennesseensis*, but none of them have ever been described or figured.

Angelin's *Marsupiocrinus dubius* is quite a different thing, probably an Actinocrinoid, as is indicated by the basal disk, which, instead of being pentagonal, is hexagonal and divided into three equal pieces.

Joh. Müller considered *M. cœlatus* a *Platycrinus* (Monatsb. Berl. Acad., 1841, p. 207), differing from the Austins, who made it the type of a separate family in which they included the genus *Crotalocrinus*. Pictet, Angelin, and Zittel view the matter as we do, and place it as a distinct genus under the Platycrinidæ.

Generic Diagnosis.—Body globular; calyx low, basin-shaped, the lower portions flat or slightly convex; sides more or less straight, surface corrugated or ornamented by fine striations; symmetry perfectly pentahedral; secondary and tertiary radials forming part of the calyx; connected laterally by a single interradial plate.

Basals three, large, unequal, arranged as in *Platycrinus*. Radials 2 × 5; those of the first row large, meeting laterally, bent abruptly from their connection with the basals, and forming with them a shallow cup, the middle of their upper margins excavated for the reception of a small triangular second radial, which is at least as high as wide, but often higher, and which has convex sides. This plate occupies not more than one-fourth to one-third the width of the first radials, and supports on its upper sloping margins the secondary radials. Secondary radials 2 × 5, enveloping the little bifurcating plate entirely except below. They are comparatively large, pentagonal to heptagonal, meeting by their short inner sides above the apex of the small bifurcating plate, and resting with their lower sides upon the upper margin of the first radial, filling the greater part of it. In some cases they touch with their outer edges the interradials, and support upon their long upper sides several small plates which pass gradually into the arms. In other cases there is on either side of these plates, and between them and the interradial, another plate of about the same size, which sometimes rests also partly on the first radial, and forms the first of a series of three tertiary radials, which support the outer arm on each side of the ray. One, and sometimes two similar tertiary radials support each of the inner arms of the ray. In forms like the last, the secondary radials seem to be bifurcating plates, supporting on each upper sloping face a series of tertiary radials leading to an arm.

Arms twenty, sometimes perhaps only ten; composed of a double series of interlocking joints, either throughout their entire length, or all except near the base, where there are sometimes single cuneiform joints passing gradually into a double series. Arm furrow deep and wide; pinnules long, composed of round joints, somewhat contracted in the middle and widening toward the articulations.

Interradial plate large, higher than wide, supported upon the upper sloping corner of the first radials, and connecting the secondary and frequently the tertiary radials with the body. Posterior side of calyx in no way distinct from the other sides.

Vault low, hemispherical, composed of a larger number of plates than usually found in this family; plates small, particularly the radial dome plates. These are generally formed into narrow ridges, which bifurcate twice within the body. Interradial dome plates larger than the radial; apical plates not prominent and identified with difficulty; interpalmar spaces paved with small pieces. Anus subcentral, tubular, or perhaps in form of a simple opening (?).

Column round, composed of rather large joints alternating with small ones; central perforation obtusely pentagonal, considerably larger than in *Platycrinus*.

Geological Position, etc.—Marsupiocrinus is strictly an Upper Silurian genus, and is found both in Europe and America.

We recognize the following species:—

1839. **Marsupiocrinus cœlatus** Phillips. Type of the genus. Murchison's Silur. Syst., p. 672, Pl. 18, fig. 1; Austin, 1842. Ann. and Mag. Nat. Hist., x, p. 109. Upper Silurian. Dudley, Eng.

1878. **Marsupiocr. depressus** Angelin. Icon. Crin. Suec., p. 3, Pl. 10, figs. 15–17. Upper Silurian. Gothland, Sweden.

1878. **Marsupiocr. pulcher** Angelin. Icon. Crin. Suec., p. 3, Pl. 22, figs. 27, 28; and Pl. 27, figs. 4, 4 a. Upper Silurian. Gothland, Sweden.

1878. **M. radiatus** Ang. Icon. Crin. Suec., p. 2, Pl. 10, figs. 18–21. Upper Silurian. Gothland, Sweden. This species was erroneously referred by Hisinger to **Eucalyptocrinus rosaceus** Goldf.

1878. **M. rugulosus** Ang. Icon. Crin. Suec., p. 2, Pl. 22, fig. 1. Upper Silurian. Gothland, Sweden.

*1860. **M. Tennesseensis** F. Roemer. (**Platycr. Tennesseensis**) Sil. Fauna. West Tenn., p. 35, Pl. 3, figs. 4, a–e; Shumard, 1866. **Cupellæcrinus Tennesseensis**, Cat. Pal. Foss., pt. i, p. 362. Niagara Gr., Upper Silurian. Decatur Co., Tenn.

*1861. **M. tentaculatus** Hall. (**Platycr. tentaculatus**) Pal. New York, iii, p 116, Pl. 5, figs. 1–4. Lower Helderberg Gr., Upper Sil. Schoharie, New York.

5. PLATYCRINUS Miller.

1821. Miller. Hist. of the Crinoidea, p. 73.
1833. Goldfuss, in part. Petrefact. Germ., i.
1835. Agassiz, in part. Mem. Soc. Neuchat., i, p. 197.
1836. Phillips. Geol. of Yorkshire, ii, p. 204.
1839. Goldfuss, in part. Nov. Acta. Ac. Leop., xix, p. 343.
1841. Joh. Müller. Monatsb. Berl. Akad., i, p. 207.
1842. T. Austin. Ann. and Mag. Nat. Hist., x, p. 109.
1843. T. Austin. Ibid., xi, p. 199.
1843. T. Austin. Mon. Rec. Foss. Crin., p. 6.
1849. McCoy. Ann. and Mag. Nat. Hist. (ser. 2), iii, p. 146.
1850. D'Orbigny. Prodr. de Paléont., i, p. 156.
1852. D'Orbigny. Cours. Elém. de Paléont., ii, p. 242.
1852. Quenstedt, in part. Handb. d. Petrefakt., p. 619.
1853. De Koninck and Lehon. Recherch. Crin. Belg., p. 155.
1855. F. Roemer. Lethæa Geogn. (Ausg. iii), p. 242.
1857. Pictét. Traité de Paléont., iv, p. 330.
1858. Hall. Geol. Rep. Iowa, i, Pt. ii, p. 525.
1866. Meek and Worthen. Geol. Rep. Ill., ii, p. 170.
1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 243.

1879. Zittel. Handb. d. Palæontologie, p. 364.
Not Phill., 1841. Pal. Foss. Cornwall, p. 28. = *Hexacrinus.*
Not F. Roemer, 1844. Rhein. Ueberg. Geb., p. 63. = *Coccocrinus.*
Not D'Orbigny, 1850. Prodr. d. Pal., i, p. 103. = *Hexacrinus.*
Not F. Roemer, 1851. Foss. West Tenn., p. 35. = *Marsupiocrinus.*
Not Hall, 1861. Pal. N. York, iii, p. 113. = *Cordylocrinus* and *Marsupiocrinus.*
Not Schultze, 1866. Echin. Eifl., p. 68. = *Storthingocrinus.*
Not Lyon, 1869. Am. Phil. Soc., xiii, p. 459. = *Hexacrinus.*
Syn. *Astropodia* Ure., 1797. Hist. of Rutherglen.
Syn. *Nave Encrinite* Parkinson, 1811. Org. Rem., vol. ii.
Syn. *Encrinites* Schlottheim, 1823. Nachtr. Petrefaktenk.
Syn. *Centrocrinus* Austin, 1843. Rec. and Foss. Crin., p. 6
Syn. *Pleurocrinus* Austin, 1843. Rec. and Foss. Crin., p. 6.
Syn. *Edwardsocrinus* D'Orbigny, 1850. Prodr. d. Paléont, i, p. 156.
Syn. *Edwardsocrinus* D'Orbigny, 1852. Cours. Elém., ii, p. 145.
Syn. *Edwardsocrinus* Pictét, 1857. Traité de Pal., iv, p. 331.

Platycrinus was correctly defined by Miller, and his original species with the single exception of *Pl. pentangularis*, have been retained in the genus ever since. This species, described from an imperfect specimen, was made by D'Orbigny the type of his genus *Dimorphocrinus* (Prodr., i, p. 155), but is evidently a *Pentremites.*

Austin supposed the basal disk to be undivided in *Platycrinus*, and admitted into it species which have a large anal plate in line with the first radials, but such only in which he thought the base to be composed of a single piece; he refers all species, in which he had "observed a tripartite base," to his genus *Hexacrinus*, whether they have an anal plate or not.

The several species which Goldfuss placed under *Platycrinus* embrace very different forms, only comparatively few of which can be retained, and some of them must be arranged under distinct families.

Phillips' two species, from the Devonian of Cornwall, have been placed with Devonian species from other localities under *Hexacrinus.*

Roemer's *Platycrinus rosaceus* is a *Coccocrinus*, his *P. Tennesseensis*, and Hall's *P. tentaculatus*, both from the Upper Silurian, have been referred by us to *Marsupiocrinus;* Hall's *P. parvus*, *P. plumosus* and *P. ramulosus* to *Cordylocrinus.*

Schultze, in 1866, described under *Platycrinus* several species from the Eifel, which he found to differ from that genus in having no interradials, and, as he supposed, no solid ventral covering. He proposed, in case a separation should be found advisable, to call this form *Storthingocrinus*. We have no specimens for comparison, but if the figures are correct, we cannot doubt that these species are not only generically distinct, but belong to a different family. In the entire absence of interradial plates they resemble *Symbathocrinus*, and they seem to have been, like other genera of that group, covered exclusively by apical dome plates resting directly upon the external articulating facets of the first radials. We accordingly recognize the genus, but remove it to the Symbathocrinidæ.

Edwardsocrinus D'Orbigny, as previously stated, is nothing but a young *Platycrinus*. *Eucladocrinus* Meek, is a more mature form in a phylogenetic sense, and is therefore properly separated as a subgenus.

Platycrinus, as now restricted, includes species with an anal tube, and those in which the opening is directly through the vault. The tube has been represented by the two Austins and by De Koninck and Lehon as extending almost to the height of the arms, heavy and rounded at the distal end. We fear that some of their figures are more ideal than real; at least we never saw an American species with so long a tube. Where we have observed it, the tube is heavy, but short, and we doubt whether in any species it extended to more than two-thirds the height of the arms, if indeed as high. Nor is the upper end closed, as the Austins supposed, nor valvate; it has a small opening, and this, without being lateral, is somewhat excentric. The opening through the vault, where there is no tube, is located more or less laterally, never centrally, and usually at the top of a wart-like process, which may perhaps be considered a rudimentary tube.

The two Austins attempted a division of the genus, based upon the form of the anus. They proposed to place under *Platycrinus* only species with a "central *oral* tube;" those with a "valvate, unobtrusive *mouth*, or *mouth* capable of being withdrawn into the visceral cup," they called *Centrocrinus;* and those with a "*mouth* placed laterally, or not central," *Pleurocrinus*. Some of these characters are not in accordance with the facts. The so-called mouth, by which they meant the anus, is always excentric, and a withdrawal of the tube into the body, as suggested, is an entire impossibility. The species of this genus are so numerous that a sub-division would be very desirable, but even a subgeneric separation, based upon the presence or absence of an anal tube, upon which other genera of this family have been successfully divided, cannot be practically carried out at present, for the reason that these parts are known only in comparatively few species, and we have been unable to discover any additional characters by which to separate the two forms. We have, however, added *Pleurocrinus* in brackets, wherever the species is known to possess a simple opening, and it may be said that, as a pretty general rule, species of their kind have a more discoid form, while those with a tube have a more elongate body; but there are exceptions in both cases, and often the facts are exactly the reverse.

Generic Diagnosis.—Body spheroidal; low discoid to elongate. Calyx composed of basals and first radials, without anal plates intervening; all succeeding radials embraced in the free rays; surface of plates variously ornamented; symmetry almost equilateral.

Basals three, unequal; one quadrangular, the other two pentangular and twice as large. They are cemented together by their sides and form a flat disk, or a more or less shallow cup, the smaller basal being located below the suture between the anterior and left lateral radials. Primary radials 2 × 5; the first very large, about quadrangular in outline, the second small, triangular or pentagonal, resembling an arm plate in form. Second radial inserted upon the excavated upper margin of the first, or upon this and a projecting callosity or thickening of the margin. The plate is sometimes so small that even both radials of the second order rest within the excavation of the first plate. The orders of radials vary in number, corresponding to the number of arms in the species; each order consisting of two plates, both wider than high, the second bifurcating. All the radials from the second primary up, are placed into free rays, from which the arms are given off alternately from opposite sides, with two arms to the last bifurcation.

Arms long, rather heavy, composed of a double series of plates, which have the same style of ornamentation as the plates of the calyx. In the younger stage, the arms are composed of single wedge-form joints, giving off pinnules in a zigzag form. Pinnules long, slender, composed of rounded joints, closely packed together; their ventral furrows covered by two rows of alternate pieces.

Interradials, one to each space, placed between the free rays; supported by the first radials, but not touching the second primary or any other radial plate.

Dome elevated, composed of comparatively few and large plates; apical dome plates prominent; the central and the four large proximal pieces nodose or even spiniferous. Radial regions somewhat elevated, constructed of a double row of larger or smaller pieces, alternately arranged, which, decreasing in size, extend to the extremities of the free rays. Interradial spaces occupied by three—rarely five—plates, smaller than the central dome plates and less nodose, but yet comparatively large, and resting upon the interradial of the calyx. On the postero-lateral sides, there are several additional plates, supporting the arms. In rare cases, the interradial dome plates of different zones are laterally connected, and the radial pieces are thereby pushed to near the edge of the disk.

Anus in form of a short, heavy tube, composed of smooth plates; abruptly rounded at its upper end; with opening nearly central (*Platycrinus*), or in form of a simple lateral opening through the vault (*Pleurocrinus*).

Column large and twisted; composed of rather large joints, which increase in length as they recede from the body: central perforation minute. The column is comparatively short, and toward the base provided with numerous lateral branches, which like the main stem, terminate in thin, almost hair-like tubes. The joints are transversely elliptic, each one being twisted so that the long diameters of opposite faces make an angle with each other; and, the articulation being in the long diameters, a rapid twist is imparted to the whole stem, permitting motion in all directions. The stem seems to be regularly articulated, which is not the case in crinoids with a round or pentagonal stem; the articulating lines run lengthwise of the faces of the joints and consist of a long ridge along the middle, with deep depressions on either side, which latter were evidently filled by ligament. The column forms one of the most characteristic features of the genus.

Geological Position, etc.—*Platycrinus*, as here defined, is almost exclusively a Subcarboniferous genus, only two small species (one of them doubtful) being known from the upper part of the Devonian. It is found most abundantly in rocks of the Burlington epoch, which embraces the lower portions of the Subcarboniferous, it ceases to exist at the close of the St. Louis limestone. No other genus of the Palæocrinoidea has so great a number of species, is so abundantly represented, and has so wide a geographical distribution.

We recognize the following species:—

1861. **Platycrinus æqualis** Hall. Desc. New Sp. Crin., p. 117; also Geol. Rep. Ill., v, p. 456, Pl. 3, fig. 8. Upper Burlington limestone. Burlington, Iowa.

1850. **Pl. americanus** Owen and Shumard. Journ. Nat. Sci. Phila. (ser. ii), ii; also 1852. U. S. Geol. Rep. Iowa, Wis. and Minn., p. 594, Pl. 5 b, figs. 1 a, b. Lower Burlington limestone. Burlington, Iowa.

Syn. **Pl. truncatus** Hall. 1858, Geol. Rep., Iowa, i, pt. ii, p. 537. Hall in this case described a young specimen of **Pl. americanus**. The lower part of the arms are composed of single, wedge-form joints, giving off the pinnules in a zigzag arrangement.

1861. **Pl. asper** Meek and Worthen. (**Pleurocrinus**) Proc. Acad. Nat. Sci. Phila., p. 129; also 1868, Geol. Rep. Ill., iii, p. 468, Pl. 18, fig. 9. Upper Burlington limestone. Burlington, Iowa.

1853. **Pl. arenosus** De Koninck and Lehon. Recherch. Crin. Carb. Belg., p. 182, Pl. 5, fig. 7. Upper part of Mountain limestone. Tournay, Belgium.

(?) 1838. **Pl. armatus** Münster. Beitr. zur Petref., vol. i. Mountain limestone (?). Tournay, Belgium (?).

1853. **Pl. Austinianus** De Koninck and Lehon.†[1] Recherch. Crin. Carb. Belg., p. 169, Pl. 5, figs. 3 a, b. Mountain limestone. Tournay, Belgium.

Syn. **Pl. trigintidactylus** Aust. (in part). Mon. Rec. and Foss. Crin., Pl. 3, fig. 1 a (not fig. 1 b-g).

1875. **Pl. bedfordensis** Hall. Geol. Surv. Ohio, Pal. ii, p. 161, Pl. 13, fig. 4. Erie Shale, Waverly Gr. Bedford, Ohio.

1879. **Pl. bonoensis** White. Proc. Acad. Nat. Sci. Phila., p. 30; also 1880, Hayden's U. S. Geol. Surv. Invert. Pal., No. 8, p. 160, Pl. 40, fig. 5 a. Lower part of Keokuk limestone. Lawrence and Floyd Co., Ind.

1861. **Pl brevinodus** Hall. Desc. New Sp. Crin., p. 4; also Bost. Jour. Nat. Hist. p. 286; separate photog. plate 2, fig. 5. Keokuk limestone. Keokuk, Iowa.

1850. **Pl. burlingtonensis** Ow. and Sh.† Jour. Acad. Nat. Sci. Phila. (new ser.), ii, pt. i; also 1852, U. S. Geol. Rep. Iowa, Wis. and Minn., p. 589, Pl. 5 a, fig. 5. Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 452, Pl. 3, figs. 6 a, b, c. Lower Burlington limestone. Burlington, Iowa.

Syn. **Pl. exsertus** Hall. 1858, Geol. Rep. Iowa, i, pt. ii, p. 539. Described from a young specimen.

Syn. **Pl. inornatus** McChesney. 1860, Desc. New Pal. Foss., p. 6; also **Pl. burlingtonensis**, Chicago Acad. Sci., i, p. 9, Pl. 4, fig. 3.

1861. **Pl. calyculus** Hall. Desc. New Sp. Crin., p. 16. Burlington limestone. Burlington, Iowa. Hall's description is too imperfect for identification.

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[1] In species marked †, an anal tube has been observed.

1861. **Pl. canaliculatus** Hall.† Geol. Rep. Iowa, i, pt. ii, p. 539. Upper Burlington limestone. Burlington, Iowa.

1858. **Pl cavus** Hall. (Pleurocrinus) Geol. Rep., Iowa, i, pt. ii, p. 527, Pl. 8, figs. 1 a, b. Upper Burlington limestone. Burlington, Iowa.

1836. **Pl. contractus** Phillips (Gilbertson). Geol. Yorkshire, p. 204, Pl. 3, fig. 25. McCoy, 1844, Carb. Foss. Ireland, p. 175; D'Orbigny, 1849, Prodr., i, p. 156. Mountain limestone. Ireland and England.

1863. **Pl. contritus** Hall. 17th Rep. N. Y. St. Cab., p. 54; also Geol. Rep. Ohio, Pal. ii, p. 166, Pl. 11, fig. 4. Waverly Gr. Richfield, Ohio.

1850. **Pl. corrugatus** Ow. and Sh, (Pleurocrinus). Jour. Acad. Nat. Sci. Phila. (new ser.), ii, pt. i; also 1852, U. S. Geol. Surv. Iowa, Wis. and Minn., p. 589, Pl. 5 a, figs. 2 a-e. Lower Burlington limestone. Burlington, Iowa.

Syn. **Pl. striobrachiatus** Hall. 1861, Desc. New Sp. Crin., p. 4; also Bost. Jour. Nat. Hist., p. 287, separate photogr. plate 2, figs. 2, 3.

1849. **Pl. diadema** McCoy. Ann. and Mag. Nat. Hist. (ser. 2), iii, p. 246. Mount limest. North Ireland.

1850. **Pl. discoideus** Ow. and Sh. (**Pleurocrinus**) Jour. Acad. Nat Sci. Phila. (new ser.), vol. ii, pt. i; also 1852, U. S. Geol. Surv. Iowa, Wisc. and Minn., p. 588, Pl. 5 a, figs. 1 a, b (not **Pl. discoideus** Hall, Geol. Rep. Iowa, i, pt. ii, Pl. 8, figs. 8 a, b = *Eucladocr. pleurovimenus* White). Lower Burlington limest. Burlington, Iowa.

Syn. **Pl. multibrachiatus** Meek and Worthen. 1861, Proc. Acad. Nat. Sci. Phila., p. 134.

Syn. **Pl. excavatus** Hall. 1861, Desc. New Sp. Crin., p. 7; also Bost. Jour. Nat. Hist., p. 286.

1862. **Pl. eboraceus** Hall. 15th Rep. N. Y. St. Cab., p. 119, separate photog. Pl. 1, figs. 16, 17; Bigsby, 1878, **Hexacr. eboraceus.** Thesaurus Devon., p. 18. Hamilton Gr. Livingstone Co., N. York.

1861. **Pl. elegans** Hall.† Desc. New Sp. Crin., p. 4; also Bost. Jour. Nat. Hist., p. 285. Upper Burlington limest. Burlington, Iowa.

1836. **Pl. ellipticus** Phillips. Geol. Yorkshire, p. 204, Pl. 3, fig. 19 (not fig. 21). D'Orbigny, 1849, Prodr. i, p. 156. Mount. limest. Bolland, England.

Probably synonym of **Pl. granulatus** Miller.

1861. **Pl. eminulus** Hall. Desc. New Sp. Crin., p. 17. Lower Burlington limest. Burlington, Iowa.

1862. **Pl. eriensis** Hall. 15th Rep. N. Y. St. Cab., p. 119. Hamilton Gr. Erie Co., New York.

This is the only species in which three radials have been observed, the upper evidently forming a syzygium. It may possibly belong to **Cordylocrinus.**

1844. **Pl. expansus** McCoy. Carb. Foss. Ireland, p. 175, Pl. 25, figs. 18, 19; D'Orbigny, 1849, Prodr, i, p. 156; Roemer, 1855, Lethæa Geogn. (Ausg. 3), 1st Periode, p. 245, Pl. 4^1, figs. 14 a, b. Mount. limest. Ireland.

1860. **Pl. Georgii** Hall. Sup. Geol. Rep. Iowa, p. 82, Pl. 1, fig. 7. Warsaw limest. Warsaw, Ill.

1836. **Pl. gigas** Gilbertson (Phillips). Geol. of Yorkshire, p. 204, Pl. 3, figs. 22, 23; Austin, 1842, Ann. and Mag. Nat. Hist., x, p. 108; also 1843, Mon. Rec. and Foss. Crin., p. 39, Pl. 4, figs. 1 a-c. Mount. limest. Bolland, England.

1861. **Pl. glyptus** Hall (**Pleurocrinus**). Desc. New Sps. Crin., p. 16. Upper Burlington limest. Burlington, Iowa.

A mere variety of **Pl. sculptus** Hall.

1853. **Pl. granosus** De Koninck and Lehon (**Pleurocrinus**). Recher. Crin. Carb. Belg., p. 183, Pl. 6, figs. 6 a-i. Mount. limest. Tournay, Belgium.

1821. **Pl. granulatus** Miller. Hist. Crinoidea, p. 81, Pl. 4, figs. 1-3; Schlotheim, 1822, Nachtr. zur Petref., i, p. 85; Ibid. ii, p. 97, Pl. 26, figs. 3 a, b, c; Blainville, 1830, Dict. des Sci. Nat., lx, p 243; Agassiz, 1835, Mem. de la Soc. des Sci. de Neuchatel, i, p. 197; De Koninck, 1842, Desc. Anim. Foss. Carb. de Belg., p. 43, Pl. F, figs. 2 a, b; Portlock, 1843, Geol. of Londonderry, p. 350, Pl. 16, fig. 4; Austin, 1843, Mon. Rec. and Foss. Crin., p. 33, Pl. 3, figs. 2 i-o; McCoy, 1844, Carb. Foss. Ireland, p. 176; De Koninck and Lehon, 1853, Recherch. Crin. Carb. Belg., p. 179, Pl. 6, figs. 5 a-b. Mount. limest. England, Ireland and Belgium.

1863. **Pl. graphicus** Hall. 17th Rep. N. Y. St. Cab., p. 55; also 1875, Geol. Surv. Ohio, Pal. ii, p. 166, Pl. 11, fig. 2. Waverly Gr. Richfield, Ohio.

1865. **Pl. Halli** Shumard (**Pleurocrinus**). Catal. Pal. Foss. North America, p. 388 (Trans. Acad. Sci. St. Louis, vol. ii). Upper Burlington limest. Burlington, Iowa.

This species was at first described and figured by Hall as **Pl. planus** Ow. and Sh., Geol. Rep. Iowa, i, pt. ii, p. 533, Pl. 8, figs. 6 a, b. It resembles **Pl. incomptus** White, in form and lack of ornamentation, but the latter has six, or exceptionally seven to eight arms to each ray, while **Pl. Halli** has twelve or even sixteen arms to the ray.

Syn. **Pl. olla** Hall (not De Kon. and Lehon). Desc. New Sp. Crin., p. 16.

1873. **Pl. Haydeni** Meek. Hayden's U. S. Geol. Surv. for 1872, p. 469; also White, Ann. Rep. U. S. Geol. Surv. Terr. for 1878, p. 122, Pl. 33, fig. 7 a. Subcarboniferous.

1865. **Pl. hemisphericus** Meek and Worthen (**Pleurocrinus**). Proc. Acad. Nat. Sci. Phila., p. 162; also Geol. Rep. Ill., iii, p. 466, Pl. 16, fig. 9, and vol. v, p. 16, figs. 6 a, b, c. Keokuk limest. Crawfordsville, Ind.; also Burlington and Keokuk Transition beds at Burlington and Nauvoo.

1863. **Pl. incomptus** White. Bost. Jour. Nat. Hist., vii, p. 503; also Meek and Worth., 1873, Geol. Rep. Ill., v, p. 459, Pl. 3, fig. 7. Upper Burlington limest. Burlington, Iowa.

1836. **Pl. laciniatus** Gilbertson (Phillips). Geol. of Yorkshire, p. 204, Pl. 3, fig. 18; Austin, 1843, Ann. and Mag. Nat. Hist., x, p. 109, and Mon. Rec. and Foss. Crin., p. 42, Pl. 5, figs. 1 a-c; D'Orbigny, 1849, Prodr. i, p. 156. Mount. limest. Bolland, England.

1821. **Pl. lævis** Miller.† Hist. Crinoidea, p. 74, Pl. 1, fig. 1-9, and 13-18, and Pl. 2, figs. 1-4, and 52-56 (the other figures have been referred by De Koninck to several other species). Schlotheim, 1822, Nachtr. zur Petref., i, p. 84; Ibid., 1823, vol. ii, p. 94, Pl. 25, figs. 4 a and 4 e; Goldfuss, 1833, Petref. Germ., i, p. 188, Pl. 58, figs. 2 a-e; Blainville, 1834, Manuel de Actinocr., p. 262; Agassiz, 1835, Mem. Soc. de Neuchatel, p. 197; Bronn, 1835, Lethæa Geogn., i, p. 60; Milne-Edwards, 1836, Anim. s. vert. de Lamarck, ii, p. 665; De Koninck, 1842, Desc. Anim. Carb. de Belgique, p. 41, Pl. F, fig. 1 c and e (the others excluded); Austin, 1843, Monog. Rec. and Foss. Crin., p. 8, Pl. 1, figs. 1 a-n; McCoy, 1844, Syn. Carb. Foss. Ireland, p. 176; Pictét, 1846, Traite de Paléont., iv, p. 200, Pl. 9, fig. 18. Mountain limest. England, Ireland and Belgium.

1875. **Pl. lodensis** Hall. Geol. Surv. Ohio, Pal. ii, p. 168, Pl. 11, fig. 3. Waverly Gr. Medina Co., Ohio.

1849. **Pl. megastylus** McCoy. Ann. and Mag. Nat. Hist. (ser. ii), p. 248. Mount. limest. Bolland, Eng.

1836. **Pl. mycrostylus** Phillips. Geol. of Yorkshire, p. 204; Austin, 1842, Ann. and Mag. Nat. Hist., x, p. 109. Mount. limest. Bolland, England.

1842. **Pl. mucronatus** Austin. (Figured by Phillips as **Pl. lævis**, Geol. Yorkshire, Pl. 3, figs. 14, 15.) Ann. and Mag. Nat. Hist., x, p. 109, and xi, p. 199; also 1843, Mon. Rec. and Foss. Crin., p. 22, Pl. 2, fig. 1, and Pl. 5, fig. 2. Subcarboniferous. England.

1853. **Pl. Mullerianus** De Kon. and Leh.† Recher. Crin. Carb. Belg., p. 171, Pl. 5, figs. 4 a, b, c, d. Mount. limest. Tournay, Belgium.

1865. **Pl. niotensis** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 162; also Geol. Rep. Ill., p. 513, Pl. 20, fig. 3. Keokuk limest. Niota and Nauvoo, Ill.

1858. **Pl. nodulosus** Hall (not Goldfuss, 1833 = *Symbathocrinus*). Geol. Rep. Iowa, pt. ii, p. 541. Lower Burlington limest. Burlington, Iowa.

1858. **Pl. nodobrachiatus** Hall (not Hall, 1861). Geol. Rep. Iowa, i, pt. ii, p. 542. Burlington limest. Burlington, Iowa.

Described from a young specimen, probably of **Pl. americanus.**

1858. **Pl. nucleiformis** Hall. (**Pleurocrinus.**) Geol. Rep. Iowa, i, pt. ii, p. 540. Lower Burlington limest. Burlington, Iowa.

1853. **Pl. olla** De Kon. and Leh. (not **Pl. olla** Hall, 1861 = *Pl. Halli* Shum.). Recher. Crin. Cab. Belg., p. 172, Pl. 5, fig. 5. Mount. limest. Tournay, Belgium.

1844. **Pl. ornatus** McCoy (not **Pl. ornatus** Goldfuss, 1833 = *Hexacrinus*). Carb. Foss. Ireland, p. 176, Pl. 25, fig. 1. D'Orbigny, **Edwardsocrinus ornatus,** 1849. Prodr. i, p. 157; also Course Elém. ii, p. 145; **Pl. ornatus** De Kon. and Leh., 1853, Recher. Crin. Carb. Belg., p. 177, Pl. 6, figs. 4 a, b, c; Pictét, **Edwardsocr. ornatus,** 1857, Traité de Pal. iv, p. 330, Pl. 101, fig. 15. Mount. limest. Ireland, and Tournay, Belg.

This is evidently a young **Platycrinus,** with the arms as yet in an immature or embryonic state.

1860. **Pl. ornigranules** McChesney. Desc. New Pal. Foss., p. 5; also Chicago Acad. Sci., i, p. 3, Pl. 5, fig. 8. Lower Burlington limest. Burlington, Iowa.

1861. **Pl. parvinodus** Hall. Desc. New Sp. Crin., p. 17. Lower Burlington limest. Burlington, Iowa.

1865. **Pl. parvulus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 163; Geol. Rep. Ill., v, p 555, Pl. 20, fig. 7. Chester limest. Pope Co., Ill.

1860. **Pl. penicillus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 380; also Geol. Rep. Ill., ii, p. 266, Pl. 19, figs. 6 a, b. Warsaw limest. Hardin Co., Ill.

1865. **Pl. perasper** Shumard. Catal. Pal. Foss. N. A., p. 389. Lower Burlington limest. Burlington, Iowa.

Syn. **Pl. nodobrachiatus** Hall, 1861 (not Hall, 1858). Desc. New Sp. Crin., p. 17.

1839. **Pl. pileatus** Goldf. (**Pleurocrinus.**) Acta Nov. ac. Leop., xix, p. 343, Pl. 31, fig. 7, a, b, c; Geinitz, Grundr. der Versteiner., Pl. 23, fig. 7; McCoy, 1851, Brit. Pal. Foss., Pt. ii, p. 119; De Kon. and Leh., 1853, Rech. Crin. Carb. Belg., p. 175, Pl. 6, figs. 3 a–e. Mount limest. England and Belg.

Syn. **Pl. anthleontes** Austin, 1842. Ann. and Mag. Nat. Hist., x, p. 69, and xi, p. 199; Mon. Rec. and Foss. Crin., p. 27, Pl. 2, figs. 3 k–r.

1858. **Pl. pileiformis** Hall. (**Pleurocrinus.**) Geol. Rep. Iowa, i, Pt. ii, p. 529, Pl. 8, figs. 3 a, b, c. Lower Burlington limest. . Burlington, Iowa. This species is easily distinguished from the other species with smooth plates, by having only four arms to the ray.

1850. **Pl. planus** Ow. and Sh. Jour. Acad. Nat. Sci. Phila. (Ser. ii), vol. ii, p. 57; also, 1852, U. S. Geol. Surv. Iowa, Wis. and Minn., p. 587, Pl. 5 A, figs. 4 a, c (not b, nor Geol. Rep. Ill., iii, Pl. 16, fig. 6, which are both **Pl. Pratteni** Worthen; nor Geol. Rep. Iowa, i, Pt. ii, Pl. 8, figs. 6 a, b, which are **Pl. Halli** Shum.); Geol. Rep. Ill., v, Pl. 3, fig. 5. Lower Burlington limest. Burlington, Iowa.

1860. **Pl. plenus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 380; also Geol. Rep. Ill., ii, p. 267, Pl. 20, fig. 3. Warsaw limest. Hardin Co., Ill.

1858. **Pl. pocilliformis** Hall. (**Pleurocrinus.**) Geol. Rep. Iowa, i, Pt. ii, p. 528, Pl. 8, figs. 2 a, b. Lower Burlington limest. Burlington, Iowa.

Syn. **Pl. verrucosus** White, 1863. Bost. Jour. Nat. Hist., p. 502.

1878. **Pl. prænuntius** Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 249, Pl. 2, figs. 1, 2. Upper Burlington limest. Burlington, Iowa.

1860. **Pl. Prattenanus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 379; also Geol. Rep. Ill, ii, p. 264, Pl. 20, fig. 2. St. Louis limest. Randolph Co., Ill.

1860. **Pl. Pratteni** Worthen. Trans. Acad. Sci. St. Louis, p. 569; Meek and Worthen, **Pl. planus.** Geol. Rep. Ill., iii, p. 469, Pl. 16, fig. 6. Lower Burlington limest. Burlington, Iowa.

Meek did not consider **Pl. Pratteni** distinct from **Pl. planus,** and Owen and Shumard seem to have been of the same opinion, for they figure in the U. S. Rep. Iowa, Wis. and Minn., Pl. 5 A, fig. 46 (not 4 a, e) a specimen, evidently of the former type, under the latter name.

1860. **Pl. pumilus** Hall. Supp. Geol. Rep. Iowa, p. 82, Pl. 1, fig. 6. Warsaw limest. Warsaw, Ill.

1844. **Pl. punctatus** McCoy. Carb. Foss. Ireland, p. 177, Pl. 25, figs. 15, 17. Mount. limest. Ireland.

1862. **Pl. quinquenodus** White. (**Pleurocrinus.**) Proc. Bost. Soc. Nat. Hist., ix, p. 18. Upper Burlington limest. Burlington, Iowa.

1861. **Pl. regalis** Hall. Desc. New Sp. Crin., p. 16, Separate Photog. Plate 2, fig. 6. Lower Burlington limest. Burlington, Iowa.

Syn. **Pl. Oweni** Meek and Worthen, 1861. Proc. Philad. Acad., p. 129.

1875. **Pl. richfieldensis** Hall. Geol. Rep. Ohio, Pal. ii, p. 167, Pl. 11, fig. 4. Waverly gr. Richfield, O.

1821. **Pl. rugosus** Miller (not Goldf. = *Storthingocrinus* Schultze). Hist. Crinoidea, p. 79, with plate. Figured by Cumberland in Trans. Geol. Soc., vol. v, Pl. 5, fig. 10; Phillips, 1836, Geol. of Yorkshire, p. 204, Pl. 2, fig. 20; Austin, 1842, Ann. and Mag. Nat. Hist., x, p. 109; Blainville, 1843, Man. d'Actin., Pl. 29, fig. 4; Austin, 1843, Mon. Rec. and Foss. Crin., p. 40, Pl. 4, figs. 2 d–k; McCoy, 1844, Carb. Foss. Ireland, p. 177. Mount. limest. Caldy Island, Wales, also Mendip Hills, England.

1858. **Pl. Saffordi** Hall. Geol. Rep. Iowa, i, Pt. ii, p. 634, Pl. 18, figs. 5, 6. Lower part Keokuk limest. Nauvoo and Hamilton, Ill., and Keokuk, Iowa. Probably Syn. of **Pl. sculptus.**

1858. **Pl. Saræ** Hall. Geol. Rep. Iowa, i, Pt. ii, p. 673, Pl. 17, fig. 4. St. Louis limest. St. Louis, Mo.

1861. **Pl. scobina** Meek and Worthen. Proc Acad Nat. Sci. Phila., p. 129; also Geol. Rep. Ill., iii, p. 466, Pl. 16, fig. 9. Lower Burlington limest. Burlington, Iowa.

Syn. **Pl. clytis** Hall, 1861. Bost. Jour. Nat. Hist., p. 285, Separate photogr. plates, i, fig. 4.

1858. **Pl. sculptus** Hall. Geol. Rep. Iowa, i, Pt. ii, p. 536, Pl. 8, fig. 11. Lower Burlington limest. Burlington, Iowa.

1858. **Pl. Shumardianus** Hall. Geol. Rep. Iowa, i, Pt. ii, p. 532, Pl. 8, fig. 5. Lower Burlington limest. Burlington, Iowa.

1844. **Pl. similis** McCoy. Carb. Foss. Ireland, p. 177, Pl. 26, fig. 6; D'Orbigny, Prodr. i, p. 156. Mount. limest. Ireland.

1842. **Pl. spinosus** Aust.† Ann. and Mag. Nat. Hist., x, p. 109, and xi, p. 199; also Mon. Rec. and Foss. Crin., p. 19, Pl. i, figs. 2 k, o, p, q, r, s; De Kon. and Leh., 1853, Rech. Crin. Carb. Belg., p. 165, Pl. 6, fig. 2 a, b. Mount limest. Mendip Hills, Eng., and Tournay, Belg.

Syn. **Engeniacrinites (?) hexagonus** Münster, 1839. Beitr. z. Petref. i, p. 4, Pl. 1, figs. 6 a, b; De Kon. 1842, Desc. Anim. Foss. Carb. Belg., p. 39, Pl. E, figs. 5 a, b, c.

Syn. **Pl. lævis** (in part) Miller. 1821, Hist. Crin., p. 74, Pl. 1, fig. 4 (not the other figures).

1821. **Pl. striatus** Miller. Hist. Crin., p. 82; Agassiz, 1835, Mem. Soc. des Sci. Nat., Neuchat. i, p. 196; Austin, 1842, Ann. and Mag. Nat. Hist., x, p. 109; Blainville, 1834, Man. d'Act., p. 262; De Kon., 1842, Desc. Anim. Foss. Carb. Belg., p. 44; Milne-Edwards apud Lamarck, ii, p. 666; Austin, 1843, Mon. Rec. and Foss. Crin., p. 37, Pl. 3, figs. 3 p–u. Mount. limest. Bristol, Engl.

1858. **Pl. subspinosus** Hall. Geol. Rep. Iowa, i, Pt. ii, p. 536, Pl. 8, figs. 9, 10; Meek and Worthen, 1866. **Pl. (Pleurocrinus) subspinosus**, Geol. Rep. Ill., ii, p. 173, Pl. 15, fig. 6, and vol. v, Pl. 11, fig. 2. Lower Burlington limest. Burlington, Iowa.

1860. **Pl. subspinulosus** Hall. Supp. Geol. Rep. Iowa, p. 81. Upper Burlington limest. Burlington, Iowa.

Syn. **Dichocrinus lachrymosus** Hall, 1860. Supl. Iowa Rep., p. 84.

1865. **Pl. tenuibrachiatus** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 168; also Geol. Rep. Ill., v, p. 450, Pl. 3, fig. 4. Upper Burlington limest. Burlington, Iowa.

1842. **Pl. trigintidactylus** Austin (**Pleurocrinus**). Ann. and Mag. Nat. Hist., x, p. 69; also 1844, Mon. Rec. and Foss. Crin., p. 30, Pl. 3, figs. 1 b-h (not a = *Pl. austinianus*). Mount. limest. Bristol, Eng. and Tournay, Belg.

Syn. **Pl. triacontadactylus** McCoy. 1844, Carb. Foss. Ireland, p. 177, Pl. 25, figs. 2–7.

1858. **Pl. truncatulus** Hall. Geol. Rep. Iowa, i, pt. ii, p. 538. Lower Burlington limest. Burlington, Iowa.

1821. **Pl. tuberculatus** Miller.—**Pleurocrinus**—(not **P. tuberculatus** Phillips = *Hexacrinus*). Hist. Crin., p. 81, figs. 1, 2; Schlotheim, 1822, Nachtr. z. Petref. i, p. 85, and 1823, Ib. ii, p. 97, Pl. 26, figs. 2 a-b; Agassiz, 1835, Mem. de la Soc. Nat. Sci. Neuchat., i, p. 197. Mount. limest. Mendip Hills, Eng., and Tournay, Belg.

Syn. **Pl. ellipticus** (in part) Phillips. Geol. Yorkshire, ii, Pl. 3, fig. 19 (not 21); also Austin, Mon. Rec. and Foss. Crin, Pl. 4, figs. 3, p to u; McCoy, Carb. Foss. Ireland, p. 177.

1858. **Pl. tuberosus** Hall. Geol. Rep. Iowa, i, pt. ii, p. 534, Pl. 8, figs. 7 a, b; Meek and Worth., 1866, **Pleurocr. tuberosus**, Geol. Rep. Ill., ii, p. 172. Upper Burlington limest. Burlington, Iowa.

1849. **Pl. vesiculus** McCoy. Ann. and Mag. Nat. Hist., p. 246. Mount. limest. Derbyshire, Eng.

1875 (?). **Pl. vexabilis** White. Wheeler's U. S. Survey, West of 100th merid., iv, Pal. p. 81, Pl. v, fig. 2. We doubt if this is a Platycrinus.

1858. **Pl. Wortheni** Hall. Geol. Rep. Iowa, i, pt. ii, p. 530, Pl. 8, fig. 4. Burlington limest. Burlington, Iowa.

1850. **Pl. Yandelli** Ow. and Sh. Jour. Acad. Nat. Sci. Phila. (new ser.), ii, pt. i; also U. S. Geol. Surv. Iowa, Wisc. and Minn., p. 587, Pl. 5 A, figs. 6 a, b. Lower Burlington limest. Burlington, Iowa.

Subgenus **EUCLADOCRINUS** Meek.

1871. Meek. Hayden's Rep. U. S. Surv. of Terr., p. 373.
1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 243.
Syn. *Platycrinus* White, in part. Proc. Bost. Soc. Nat. Hist., p. 17.

The name *Eucladocrinus* was proposed by Meek in 1871 (Hayden's Rep. U. S. Survey of the Territories, p. 373) to designate a subgeneric group under *Platycrinus*, of which *Pl. pleuroviminus* White is the type.

In the structure of the calyx, this form presents no apparent difference from *Platycrinus*, and it embraces species with a low, broad cup shaped, and with an elongate body. It is characterized, however, by having the radial series of the body, both dorsal and ventral, greatly extended in the form of tubular free rays, which bear the arms alternately on either side throughout their entire length. These rays, in all the known species, divide on the second radial into two branches, which remain joined by their inner sides for the length of three or four plates, after which they become free, giving two free branches to each ray, or ten in all. A tubular passage, arched over by the extensions of the vault, runs the whole length of the rays, and these tubes, after uniting on the inside of the second radial, connect with the visceral cavity.

The arms are composed of a double series of interlocking joints, and bear slender, single-jointed pinnules.

This type bears the same relation to *Platycrinus* that *Steganocrinus* does to *Actinocrinus*, and *Melocrinus* to *Mariacrinus;* and the two are very closely connected by transition forms such as *Pl. prænuntius*, in which the free ray structure is clearly begun, the radial areas being produced to the extent of ten or twelve plates.

The subgenus evidently represents the mature and extreme form of the *Platycrinoid* type.

Geographical Position, etc.—Found as yet only in the Subcarboniferous of America, where the following species are known:—

1878. **Eucladocrinus millebrachiatus** Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 245. Upper Burlington and Keokuk Transition bed, and lower part of the Keokuk limest. Burlington, Iowa, Nauvoo and Niota, Ill.

1871. **Eucladocr. montanaensis** Meek. Hayden's Geol. Rep. U. S. Surv. Terr., p. 373. Subcarb. Montana.

1862. **Eucladocr. pleuroviminus** White (**Platycr. pleuroviminus**). Type of the subgenus. Proc. Bost. Soc. Nat. Hist., ix, p. 17; Meek, 1870, Am. Jour. Sci. and Arts; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 249. Upper Burlington limest. Burlington, Iowa.

6. (?) COTYLEDONOCRINUS Casseday and Lyon.

1860. Casseday and Lyon. Proc. Acad. Arts and Sci., v, p. 26.
1865. Shumard. Catal. Pal. Foss. N. A. Trans. St. Louis Acad., ii, p. 360.
1877. S. A. Miller. Catal. Am. Pal. Foss., p. 74.
1879. Zittel. (*Dichocrinus.*) Handb. d. Pal., i, p. 365.

Casseday and Lyon proposed the above name for a crinoid which agrees in every respect with *Dichocrinus*, except that it has no anal plate in line with the first radials. According to the description, however, there is a deeper notch between the radials on the posterior side, and the question arises whether the type specimen was not an abnormal *Dichocrinus* in which the anal plate was wanting or imperfectly developed. The notch lies directly in line with one end of the suture which divides the basal disk, and hence the position corresponds to that of the anal in *Dichocrinus.* The bipartite base itself seems to indicate that there was normally a sixth plate above, for otherwise, according to the rule we have found to prevail among these Crinoids, one plate of the basal disk should be larger—while they are said to be equal in this form.

As described, *Cotyledonocrinus* agrees essentially in the form of the body with typical species of *Dichocrinus*, and like them has three primary radials, the first large and long, the two others small and supporting 2 × 10 secondary radials, succeeding radials forming parts of the free rays. There is a single interradial in connection with the first radials, two interradial plates above constitute a part of the vault.

The specimen has long delicate arms, which do not bifurcate, and which give off long pinnules, composed of a large number of short joints.

Column cylindrical.

Until other specimens are discovered, we must consider *Cotyledonocrinus* an abnormal form of *Dichocrinus*.

Casseday and Lyons' only species is :—

1860. **Cotyledonocrinus pentalobus.** Proc. Amer. Acad. Arts, and Sci., vol. v, p. 26. Warsaw limest. Grayson Co., Kentucky.

b. HEXACRINITES.

7. HEXACRINUS Austin.

1843. Austin. Mon. Rec. and Foss. Crin., p. 48.
1853. De Kon. and Leh. Rech. Crin. Carb. Belg., p. 160.
1855. F. Roemer. Lethæa Geogn. (Ausg. 3, Per. 1), p. 244.
1857. Joh. Müller. Neue Echin. Eifl. Kalk, p. 85.
1857. Pictet. Traité de Paléont., iv, p. 331.
1867. Schultze. Mon. Echinod. Eifl. Kalk, p. 71.
1879. Zittel. Handb. der Palæontologie, p. 365.
Syn. *Platycr.* Phil., 1841 (not 1836). Pal. Foss. Cornw., p. 28.
Syn. *Platycr.* Goldf. (in part), 1838. Nova Acta. Ac. Leop., xix, p. 343.
Syn. *Platycr.* Agas. (in part), 1835. Mem. Soc. Neuch., i, p. 197.
Syn. *Platycr.* Aust. (in part), 1842. Ann. and Mag. Nat. Hist., x, p. 109.
Syn. *Platycr.* F. A. Roemer, 1843. Verstein. d. Harzes.
Syn. *Platycr.* F. Roemer, 1851. Verh. naturh. Verein Rheinl., p. 362.
Syn. *Platycr.* D'Orbigny (in part), 1850. Prodr. Pal., i, p. 103.
Syn. *Platycr.* Lyon, 1860. Trans. Am. Philos. Soc., p. 459.

Generic Diagnosis.—Body obconical, pear-shaped or subglobose; surface generally elaborately sculptured or nodose; symmetry decidedly bilateral.

Basal disk large, in form of a shallow cup; hexagonal; composed of three equal plates. Five of its sides support a first radial each, the sixth a large anal plate, which extends to the full height of the first radials. Primary radials 2 × 5, the first very large, apparently quadrangular but actually hexagonal; increasing in width from the base up; upper margin excavated. Second radials minute, triangular, rarely filling the whole excavation, which generally encloses a part of the first secondary radials, the latter forming the base of two free appendages to each ray. The free rays and the arms proper have been rarely observed, but were apparently constructed like those of *Eucladocrinus*. In *Hexacr. limbatus*, the free rays attain three or four times the length of the body, and each one consists of a row of short cylindrical joints, which give off laterally pinnule bearing arms. These arms originate on every fourth, fifth or sixth joint, according to position, and alternately from opposite sides. The free parts of the ray in *Hexacr. brevis*,[1] are apparently more like those of *Platycrinus*.

Anal plates generally narrower, but often higher than the first radials; wider towards the top than at its junction with the basals, the upper side supporting two or three plates. Interradial series composed of a single large plate, which rests within a notch between two radials.

Vault low, hemispherical, more or less flattened, composed of comparatively few and large pieces, which are nodose, or covered with a number of small tubercles. Apical dome plates large. Anus subcentral or lateral; in form of a simple opening through the vault, or supported by a small tubercular process composed of small polygonal pieces.

Column cylindrical, the larger joints nodose or sculptured after the style of the plates of the calyx; articulating face radicularly striated; central canal small, round.

Geological Position, etc.—*Hexacrinus* is strictly a Devonian genus, and almost exclusively European, only fragments of a single species having been discovered in America.

The following species have been described:—

1838. **Hexacrinus anaglypticus** Goldf. (**Platycr. anaglypticus.**) Nova Acta ac. Leop., xix, p. 348, Pl. 32, fig. 4; Schultze, 1867, **Hexacr. anaglypticus,** Mon. Echin. Eifl. Kalk, p. 72, Pl. 8, fig. 1. Devonian. Eifel, Germany.

Syn. **Platycr. frondosus** Goldf. Bonn Museum, undefined.

Syn. **Platycr. annulatus** Goldf. Bonn Museum, undefined.

Syn. **Platycr. muricatus** Goldf. Bonn Museum, undefined.

1867. **Hexacr. bacca** Schultze. Mon. Echin. Eifl. Kalk, p. 83, Pl. 10, fig. 5. Devonian. Eifel, Germany.

1838. **Hexacr. brevis** Goldf. (**Platycr. brevis.**) Nova Acta ac. Leop., xix, i, p. 346, Pl. 32, fig. 2; Schultze, 1867, **Hexacr. brevis,** Mon. Echin. Eifl. Kalk, p. 79, Pl. 10, fig. 7. Devonian. Eifel, Germany.

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[1] We believe that *Hexacr. brevis* Goldf. (Mon. Echin. Eifl. Kalk, Pl. 10, fig. 7) is a young specimen of some other species. This is indicated not only by its small size, but also the immature character of the arms and column; it may even represent an entirely different genus.

1843. **Hexacr. Buchii** F. A. Roemer. (**Platycr. Buchii.**) Hartzgebirge, p. 9, Pl. 12, fig. 13. Devonian. Hartz, Germany.

1867. **Hexacr. callosus** Schultze. Mon. Echin. Eifel Kalk, p. 83, Pl. 9, fig. 3. Devonian. Eifel, Germany.

Syn. **Platycr. rosaceus** Goldf. (not Roemer = *Coccocrinus*). Bonn Museum, undefined.

1858. **Hexacr. costatus** Müller. Monatsb. Berl. Akad. Wissensch., p. 354; Schultze, 1867, Mon. Echin. Eifel, Kalk, p. 74. Devonian. Eifel, Germany. Probably a variety of **Hexacr. anaglypticus.**

1838. **Hexacr. elongatus** Goldf. (**Platycr. elongatus** Goldf. not Phillips.) Nova Acta ac. Leop., xix, i, p. 345, Pl. 32, fig. 1; Schultze, 1867, **Hexacr. elongatus,** Mon. Echin. Eifel Kalk, p. 74, Pl. 9, fig. 4. Devonian. Eifel, Germany.

Syn. **Platycr. Goldfussi** Münster. Beitr. z. Petrefactenk, i, p. 32, Pl. 1, figs. 2 a, b.

1838. **Hexacr. exsculptus** Goldf. (**Platycr. exsculptus.**) Nova Acta ac. Leop., xix, i, p. 347, Pl. 32, fig. 3; Schultze, 1867, **Hexacr. exsculptus,** Mon. Echin. Eifel Kalk, p. 77, Pl. 9, fig. 2. Devonian. Eifel, Germany.

1843. **Hexacr. granuliferus** F. A. Roemer. (**Platycr. granuliferus.**) Versteiner Nassau's, p. 397. Devonian. Lahnstein, Germany.

*1860 (?). **Pl. insularis** Eichwald. Lethæa Rossica, i, p. 612, Pl. 31, fig. 58. Devonian. Isle of Oesel.

There is some doubt, whether this is a *Hexacrinus*. Eichwald describes it with five radials, one of them much larger and apparently composed of two pieces, which are said to be soldered together. One of the other plates is represented as being much smaller.

1841. **Hexacr. interscapularis** Phillips. (**Platycr. interscapularis** not Miller.) Pal. Foss. Cornwall, p. 28, Pl. 14, fig. 39; D'Orbigny, 1849, Prodr. d. Paléont, p. 103; Austin, 1843, Ann. and Mag. Nat. Hist., x, p. 109; Schultze, 1867, **Hexacr. interscapularis,** Mon. Echin. Eifel Kalk, p. 79, Pl. 8, fig. 5. Devonian. Near Plymouth, Eng., and Eifel, Germany.

Syn. **Platycr. granifer** Roemer. 1852, Verh. Naturh. Verein Rheinl., ix, p. 281, Pl. 2, fig. 1; Schultze, **Hexacr. interscapularis,** Mon. Echin. Eifel Kalk, p. 79.

Syn. **Platycr. melo** Austin. 1843, Mon. Rec. and Foss. Crin., p. 48, Pl. 6, fig. 1; Schultze, **Hexacr. interscapularis,** Mon. Echin. Eifel Kalk, p. 79.

Syn. **Hexacr. depressus** Austin. 1843, Mon. Rec. and Foss. Crin., p. 49, Pl. 6, figs. 2 a-e; Schultze, **Hexacr. interscapularis,** Mon. Echin. Eifel Kalk, p. 79.

*1860. **Hexacr. Leai** Lyon. (**Platycr. Leai.**) Trans. Am. Philos. Soc., p. 259, Pl. 26, figs. g-g^1. Upper Helderberg, Dev. Louisville, Ky.

1857. **Hexacr. limbatus** Müller. Neue Echin. Eifel, p. 248, Pl. 2, fig. 1; Schultze, 1867, Mon. Echin. Eifel Kalk, p. 78, Pl. 9, fig. 1. Devonian. Eifel, Germany.

1857. **Hexacr. lobatus** Müller. Neue Echin. Eifel, p. 248, Pl. 1, figs. 10–12; Schultze, 1867, Mon. Echin. Eifel Kalk, p. 84, Pl. 10, fig. 6. Devonian. Eifel, Germany.

1843. **Hexacr. macrotatus** Austin. Mon. Rec. and Foss. Crin., p. 50, Pl. 6, figs. 3 a-d. Devonian. South Devon, England.

Syn. **Platycr. Phillipsii** D'Orbigny. 1850. Prodr. de Paléont., i, p. 103.

Syn. **Platycr. tuberculatus** Phillips, 1839 (not Miller, 1821). Pal. Foss. Cornwall, Pl. 60, fig. 39.

1867. **Hexacr. nodifer** Schultze. Mon. Echin. Eifel Kalk, p. 84, Pl. 10, fig. 3. Devonian. Eifel, Germany.

1838. **Hexacr. ornatus** Goldf. (**Platycr. ornatus** not McCoy.) Nova Acta Ac. Leop., xix, i, p. 347; Schultze, 1867, **Hexacr. ornatus,** Mon. Echin. Eifel Kalk, p. 82, Pl. 8, fig. 4, and Pl. 10, fig. 9. Devonian. Eifel, Germany.
Syn. **Hexacr. echinatus** Sandberger, 1856. Verstein. Nassau's, p. 398, Pl. 35, fig. 10.

1867. **Hexacr. pateræformis** Schultze. Mon. Echin. Eifel Kalk, p. 87, Pl. 10, fig. 4. Devonian. Eifel, Germany.

1867. **Hexacr. pyriformis** Schultze. Mon. Echin. Eifel Kalk, p. 76, Pl. 10, fig. 1. Devonian. Eifel, Germany.

1857. **Hexacr. spinosus** Müller. Neue Echin. Eifel, p. 248, Pl. i, figs. 13, 14; Schultze, 1867, Mon. Echin. Eifel Kalk, p. 75, Pl. 8, fig. 2. Devonian. Eifel, Germany.

1851. **Hexacr. stellaris** F. Roemer. (**Platycr. stellaris.**) Verh. Naturh. Verein f. Rheinl., viii, p. 362, Pl. 7, figs. 2 a, b, c; Schultze, 1867, **Hexacr. stellaris,** Mon. Echin. Eifel Kalk, p. 81, Pl. 8, fig. 3. Devonian. Eifel, Germany.

1867. **Hexacr. triradiatus** Schultze. Mon. Echin. Eifel Kalk, p. 86, Pl. 9, fig. 5. Devonian. Eifel, Germany.

1826. **Hexacr. ventricosus** Goldf. (**Platycr. ventricosus.**) Petref. Germ., i, p. 189, Pl. 58, fig. 4; Müller, 1856, Monatsb. Berl. Akad., p. 354, and 1857, Neue Echin. Eifl., p. 247, Pl. 1, figs. 3, 4; Schultze, 1867, **Hexacr. ventricosus,** Mon. Echin. Eifel Kalk, p. 85, Pl. 10, fig. 2. Devonian. Eifel, Germany.

8. **DICHOCRINUS** Münster.

1838. Münster. Beitr. zur Petrefactenk., i, p. 2.
1843. Austin. Mon. Rec. and Foss. Crin., p. 45.
1850. D'Orbigny. Prodr. de Paléont., i, p. 156.
1852. Owen and Shumard. U. S. Geol. Rep. Iowa, Wis. and Minn., p. 589.
1853. De Koninck and Lehon. Rech. Crin. Carb. Belg., p. 146.
1857. Pictét. Traité de Paléont., iv, p. 333.
1858. Hall. Geol. Rep. Iowa, i, pt. ii, p. 654 (not 689).
1860. Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 381.
1860. Hall. Supp. Geol. Rep. Iowa, p. 83.
1860. Casseday and Lyon (in part). Proc. Acad. Arts and Sci., v, p. 16.
1866. Meek and Worthen. Geol. Rep. Ill., ii, pp. 167 and 263.
1879. Zittel. Handb. der Palaeont., p. 365 (not Shumard, 1857, Trans. St. Louis Acad., i, p. 5).
Syn. (?) *Cotyledonocrinus* Cass. and Lyon. 1860, Proc. Am. Acad. Arts and Sci., v, p. 16.
Syn. *Platycrinus* Phillips (in part). Geol. of Yorkshire, ii.

There has been some difference of opinion as to the number of primary radials in *Dichocrinus.* Austin represents his *Dichocr. fusiformis,* Rec. and Foss. Crin., Pl. 5, fig. 6^b, with three small plates above the first radials; De Koninck and Lehon, in their generic formula, fix the number of primary radials at 4 × 5, on the strength of Austin's figure. On the other hand, Shumard described his two species, *D. cornigerus* and *D. sexlobatus*, with a single large radial, and none above it. Casseday and Lyon state the number of radials as 1 to 3 × 5, in which opinion Meek and Worthen coincide.

We have no doubt that the latter statement is correct, and that Austin's species is incorrectly figured, and had actually but three radials; but we have ascertained from several excellent specimens loaned to us by Prof. Worthen, that the so-called *D. cornigerus* and *D. sexlobatus* of Shumard both have a very minute second radial, which is sometimes not visible externally. These two species, however, like some others described by Casseday and Lyon, differ from the typical *Dichocrinus* in several other important points, and this has led us to arrange them in a new generic group under *Talarocrinus*, which includes every species of this form with only two primary radials. We have examined all known American species of *Dichocrinus* proper, and find they all have three primary radials.

Revised Generic Diagnosis.—Calyx deeply cup-shaped; plates delicate, rarely ornamented; symmetry distinctly bilateral.

Basals two, hexagonal, forming together an obconical or rounded cup. Radials 3 × 5. The five plates of the first series very large, their sides straight and nearly parallel; two rest on each basal piece, the anterior plate in a notch at one end of the basal suture; against the opposite end there rests a large anal plate, which is placed in line with the first radials. Succeeding radials very small, occupying scarcely more than one-fourth the width of the first. The third radials are bifurcating plates which support either the arms, or in species with more than ten arms, the higher orders of radials. Secondary, tertiary, or even quarternary radials occur according to the number of arms. These higher orders are generally in series of two plates each, exceptionally three; they are similar in appearance to ordinary arm plates, but are easily distinguished by being single-jointed; while the arm plates, from the base up, are composed of a double series of pieces.

Arms rather delicate, but they give off very long and stout pinnules composed of large joints. The pinnules form a very characteristic feature of the genus.

Anal plate almost as large as the first radials, often narrower above than below; quadrangular. Interradial plate pushed upward to the ventral side of the body, resting upon two upper margins of the first radials, which are not indented; several interradial dome plates follow in succession.

Dome depressed, and so far as known, constructed, as in some species of *Platycrinus*, with a short excentric anal tube.

Column cylindrical, with a small round canal.

The genus is most closely related to *Talarocrinus.*

Geological Position, etc.—Dichocrinus is a Subcarboniferous genus, and is found in America from the Lower Burlington limestone up to the Warsaw, where it is succeeded by *Talarocrinus.* It is also represented by a number of species in the Mountain limestone of Belgium and Great Britain.

We recognize the following species:—

1862. **Dichocrinus angustus** White. Proc. Bost. Soc. Nat. Hist., ix, p. 19. Upper Burlington limest. Burlington, Iowa.

1860. **Dichocr. constrictus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 381; also Geol. Rep. Ill., ii, p. 263, Pl. 19, figs. 2 a, b, c. Warsaw limest. Bloomington, Ind.

1860. **Dichocr. conus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 381; also Geol Rep. Ill., ii, p. 169, Pl. 16, figs. 5 a, b. Lower Burlington limest. Burlington, Iowa.

1862. **Dichocr. crassitestus** White. Proc. Bost. Soc. Nat. Hist., ix, p. 19. Upper Burlington limest. Burlington, Iowa.

1860. **Dichocr. dichotomus** Hall. Supp. Geol. Rep. Iowa, p. 85, Pl. 1, fig. 5. Warsaw limest. Warsaw, Ill.

1853. **Dichocr. elegans** De Kon. and Leh. (not Casseday and Lyon = *Talarocrinus elegans* Wachsm. and Spr.). Rech. Crin. Carb. Belg., p. 153, Pl. 4, figs. 13 a, b. Mountain limest. Tournay, Belg.

1836. **Dichocr. elongatus (Platycr. elongatus)** Phill. (not Goldf., 1838 = *Hexacrinus*). Geol. of Yorkshire, p. 204, Pl. 3, figs. 24, 26; Austin, 1843, Mon. Rec. and Foss. Crin. Mount. limest. Tournay, Belg.

1853. **Dichocr. expansus** De Kon. and Leh. (not Meek and Worthen = *Dichocr. polydactylus* Cass. and Lyon). Rech. Crin. Carb. Belg., p. 151, Pl. 4, fig. 10. Mount. limest. Belgium and England.

This species had been figured by Miller, 1821, among his **Pl. lævis** (figs. 4, 5), and by Austin as **D. radiatus.**

1860. **Dichocr. ficus** Casseday and Lyon. Proc. Am. Acad. Arts and Sci., v, p. 24; Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 500, Pl. 14, fig. 1. Keokuk limest. Crawfordsville, Ind.

In their description, the above authors state that all of the six perisomic plates are arm bearing. This is a mistake, as the anal plate supports a narrow cylindrical tube somewhat resembling an arm.

1843. **Dichocr. fusiformis** Austin. Mon. Rec. and Foss. Crin., p. 47, Pl. 5, figs. 6 a-d; De Kon. and Leh., 1853, Rech. Crin. Carb. Belg., p. 148, Pl. 4, fig. 7. Mount. limest. Mendip Hills, Eng., and Tournay, Belg.

1853. **Dichocr. granulosus** De Kon. and Leh. Rech. Crin. Carb. Belg., p. 152, Pl. 4, fig. 12. Mount. limest. Tournay, Belg.

1853. **Dichocr. intermedius** De Kon. and Leh. Rech. Crin. Carb. Belg., p. 150, Pl. 4, fig. 9. Mount. limest. Tournay, Belg.

1853. **Dichocr. irregularis** De Kon. and Leh. Rech. Crin. Carb. Belg., p. 152, Pl. 4, figs. 11 a, b. Mount. limest. Tournay, Belg.

1860. **Dichocr. lævis** Hall. Supp. Geol. Rep. Iowa, p. 83. Lower Burlington limest. Burlington, Iowa.

1869. **Dichocr. lineatus** Meek. and Worth. Proc. Acad. Nat. Sci. Phila., p. 69; also Geol. Rep. Ill., v, p. 440, Pl. 3, fig. 1. Lower Burlington limest. Burlington, Iowa.

1861. **Dichocr. liratus** Hall. Desc. New Sp. Pal. Crin., p. 5; also Bost. Jour. Nat. Hist., p. 290, Photog. Pl. 2, figs. 7, 8. Upper Burlington limest. Burlington, Iowa.

*1881. **Dichocr. ornatus** Wachsm. and Spr. (**Dichocr. sculptus** Lyon and Cass., not De Kon. and Leh., 1853). Proc. Am. Acad. Arts and Sci., v, p. 25. Keokuk limest. Hardin Co., Ky. We propose the above name, **D. sculptus** being preoccupied.

1850. **Dichocr. ovatus** Ow. and Sh. Jour. Acad. Nat. Sci. Phila. (new sr.) ii, Pt. i; also U. S. Geol. Rep. Iowa, Wis. and Minn., p. 590, Pl. 5 A, figs. 9 a–b. Lower Burlington limest. Burlington, Iowa.

1869. **Dichocr. pisum** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 69; also Geol. Rep. Ill., v, p. 440, Pl. 3, fig. 2. Lower Burlington limest. Burlington, Iowa.

1861. **Dichocr. plicatus** Hall. Desc. New Pal. Crin., p. 4; also Bost. Jour. Nat. Hist. p. 288, Phot. Pl. 2, figs. 9, 10. Upper Burlington limest. Burlington, Iowa.

1861. **Dichocr. pocillum** Hall. Desc. New Sp. Crin., p. 5; also Bost. Jour. Nat. Hist., p. 291, Phot. Pl. 2, figs. 15, 16 (Fig. 14 is evidently Meek and Worthen's **D. lævis**, which occurs in the Upper Burlington beds). Lower Burlington limest. Burlington, Iowa.

1860. **Dichocr. polydactylus** Casseday and Lyon. Proc. Am. Acad. Arts and Sci., v, p. 20. Keokuk limest. Crawfordsville, Ind.

Syn. **D. expansus** Meek and Worth (not De Kon. and Leh., 1853). Proc. Acad. Nat. Sci. Phila., p. 344; also Geol. Rep. Ill., v, p. 500, Pl. 14, fig. 1.

The original description by Cass. and Lyon is somewhat erroneous as to the arrangement of the arms, and this probably led Meek and Worthen to propose a new species. There is no doubt of the identity of the two.

1838. **Dichocr. radiatus** Münster. Type of the genus. Beitr. z. Petref., i, p. 2, Pl. 1, figs. 3 a–d; De Koninck, 1842, Desc. Anim. Foss., p. 40, Pl. i, figs. 6 a-d; Austin, 1843, Mon. Rec. and Foss. Crin., p. 45, Pl. 5, figs. 5 a–d; D'Orbigny, 1850, Prodr. de Paléont. i, p. 156; De Kon. and Leh., 1853, Rech. Crin. Carb. Belg. p. 149, Pl. 4, figs. 8 a–d; Pictét, 1857, Traité de Paléont. iv, p. 333, Pl. 101, fig. 18; Bronn, 1860, Klassen d. Thierreichs, ii, Pl. 28, figs. 9 a–b. Mount. limest. Mendip Hills, Eng., and Tournay, Belg.

1861. **Dichocr. scitulus** Hall. Desc. New Pal. Crin. p. 4; also Bost. Jour. Nat. Hist., p. 289. Lower Burlington limest. Burlington, Iowa.

1853. **Dichocr. sculptus** De Kon. and Leh. (not Cass. and Lyon, 1860). Rech. Crin. Carb. Belg., p. 154, Pl. 4, figs. 14 a, b, c. Mount. limest. Tournay, Belg.

1857. **Dichocr. simplex** Shumard. Trans. Acad. Sci. St. Louis, p. 74, Pl. 1, fig. 2; Hall, 1858, Geol. Rep. Iowa, i, Pt. ii, p. 654, Pl. 23, figs. 12 a, b. Warsaw limest. Spurgeon Hill, Ind.; also St. Mary's Landing, Mo., and Sparta, Tenn.

1850. **Dichocr. striatus** Ow. and Sh. Jour. Acad. Nat. Sci. Phila. vol. ii, Pt. i,; also U. S. Geol. Rep. Iowa, Wis. and Minn. p. 590, Pl. 5 A, figs. 10 a, b. Upper Burlington limest. Burlington, Iowa.

9. TALAROCRINUS, nov. gen.

(τάλαρος a small basket, κρῖνον a lily.)

Syn. *Dichocrinus* Shumard (in part) 1860 (not Münster). Trans. Acad. Sci. St. Louis.

Syn. *Dichocrinus* Cass. and Lyon (in part) 1860. Proc. Am. Acad. Arts and Sci., v, p. 16.

Among the species described by Shumard under *Dichocrinus* there are two, which differ materially from that genus and from *Pterotocrinus*, with which they are nearest related. Meek and Worthen, in their generic description of *Pterotocrinus* (Geol. Rep. Ill., ii, p. 290), recognized more than specific differences between the form represented by Shumard's *Dichocrinus cornigerus* and *D. sexlobatus*, and the genus *Pterotocrinus* with which these two species had been identified, and they proposed either to divide the genus into two sections, or to separate the above species from it sub-generically. Shumard afterwards and also S. A. Miller, in their catalogues placed both species under *Pterotocrinus.*

Wetherby (Cin. Journ. Nat. Hist., 1879, Apr. number) on the other hand, refers the above species to *Dichocrinus* and considers them altogether distinct from *Pterotocrinus.* In the latter conclusion he is undoubtedly correct, but we cannot see that their relations to *Dichocrinus* are any closer. They evidently form a little group by themselves, which in nature occupies a place between the two genera, forming a connecting link between them. We propose for this group the generic name *Talarocrinus* with *D. cornigerus* Shum. as the type.

Generic Diagnosis.—General form of body ovoid; composed of heavy plates. Calyx subconical; plates convex, deeply impressed at the suture lines, and hence more or less protuberant; surface smooth.

Basals two, pentagonal, precisely alike, the suture running from the posterior to the anterior side. First radials large, quadrangular, nearly as wide as high, aranged in line with the first anal plate, which is as large or larger than the radials, and of similar form. The upper edge is excavated, but not semicircular, there being an angular process in the middle. Second radials[1] very minute, often not visible externally, and resting from within against the median angular process within the articulating depression of the large radial. Their inner face is much larger, triangular in form, with concave sides. The arrangement is such that these sides, together with the outer portions of the articulating scar of the first plates, form two semicircular sockets, supporting each a small pentagonal bifurcating secondary radial, which here, as in *Pterotocrinus* and *Marsupiocrinus*, constitutes a part of the body, and in turn supports two arms, or twenty arms in all. Form of the arms unknown.

Vault generally of equal height with the calyx, decidedly lobed when viewed from above; composed of numerous small pieces, some of them spiniferous; toward the posterior side obliquely flattened, with a lateral anal aperture towards the upper end. Radial area elevated, and extending outward; interradial portions depressed, posterior side much wider. Central vault piece large, nodose or spiniferous. The four large proximal plates occupy in four of the interradial spaces the upper portion of the depression, while the two smaller ones rest partly against the radial portions of the dome, with several small anal plates and the anal aperture between them. Interradial vault pieces three, rather large, and much higher than wide. The first radial vault piece is spiniferous in most species, the succeeding plates small and nodose, arranged longitudinally in rows, forming together regular arches over the ambulacral passages within the body. There is a large elongate brachial piece between the two divisions of each ray, which at its lower end connects with the upper point of the second radial, thus giving origin to two arm openings in each ray. The anal area has three large pieces in the first series, which rest upon the anal plate of the calyx, the median one has form and size of the interradial plates, the two others are smaller. In the second series there are two plates, followed by a number of minute pieces surrounding the anal aperture, which is protuberant.

Column probably cylindrical and small, with a minute central canal.

Talarocrinus differs from *Dichocrinus* in the greater prominence of the plates in the calyx; its higher vault; in having the secondary radials forming part of the calyx, and in having the anal opening through the vault, and not at the end of a tube. It differs from *Pterotocrinus* in the very different form of the calyx; in having no tertiary radials in the calyx; in the form of the dome, and the absence of lobed processes.

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[1] Shumard described *Dichocr. cornigerus* with a single radial, but the second is present in the species though hidden from view exteriorly.

Geological Position, etc.—The genus is known only from the St. Louis and Kaskaskia groups of the United States.

We recognize the following species:—

*1857. **Talarocrinus cornigerus** Shumard. (**Dichocr. cornigerus.**) Type of the genus. Trans. Acad. Sci. St. Louis, i, p. 72, Pl. 1, figs. 1 a, b; **Pterotocr. cornigerus** Shumard, 1866, Cat. Pal. Foss. N. Amer., i, p. 393; S. A. Miller, **Pterotocr. cornigerus,** Catal. Pal. Foss., p. 89. Kaskaskia limest. Franklin Co., Ala.

*1860. **Talarocr. elegans** Cass. and Lyon. (**Dichocr. elegans.**) Proc. Am. Acad. Arts and Sci., v, p. 22. St. Louis limest. Edmonson Co., Ky.

*1857. **Talarocr. sexlobatus** Shumard. (**Dichocr. sexlobatus**). Trans. Acad. Sci. St. Louis, vol. i, p. 6, Pl. i, figs. 3 a, b, c; S. A. Miller (**Pterotocr sexlobatus**), Catal. Pal. Foss., p. 89. Kaskaskia limest. Russelville, Ky.

*1860. **Talarocr. symmetricus** Cass. and Lyon. (**Dichocr. symmetricus.**) Proc. Am. Acad. Arts and Sci., vol. v, p. 22. Kaskaskia limest. Edmonson Co., Ky.

10. PTEROTOCRINUS Lyon and Casseday.

1859. Lyon and Casseday. Am. Journ. Sci. and Arts, xxix, p. 68.
1866. Meek and Worthen. Geol. Rep. Ill., ii, p. 288.
1879. Wetherby. Journ. Cin. Soc. Nat. Hist. (April).
1879. Wetherby. Ibid. (October No.).
1879. Zittel. Handb. d. Palaeont., i, p. 365.
Syn. *Asterocrinus* Lyon, 1857 (not Münster). Geol. Rep. Ky., iii, p. 472.

Pterotocrinus was first described in 1857 by Lyon under the name of *Asterocrinus*, which, being previously occupied by Münster, was changed to the former in 1859 by Lyon and Casseday.

Meek and Worthen, in revising the genus in 1866, indicated in their generic formula four series of interradial plates, which is evidently a mistake, as that order of plates is entirely absent in the calyx. They further changed the term "wings or lobed pieces" of Lyon into "interbrachial appendages."

In 1879, Prof. Wetherby, who had obtained very perfect specimens from Kentucky, published some new and interesting observations on the genus, and described in the April and October numbers of the Journ. of the Cincin. Soc. Nat. Hist., three new species. He considered the small plates which had been recognized by Meek and Worthen as second radials, to be mere accessory pieces. These plates are exceedingly small and rudimentary in this genus, sometimes almost obsolete; but in their minuteness they are clearly the analogues of the second primary radials in other genera, and should be so described.

Generic Diagnosis.—Calyx depressed, saucer-shaped, much wider than high; symmetry bilateral. Vault high, pyramidal, pentagonal in outline, crowned by five wing-like lateral extensions or processes, which form one of the most characteristic features of this remarkable genus. Plates without surface ornamentation.

Basals two, large, of similar form, pentagonal, the suture running from the anterior to the posterior side; they form a shallow cup, with a central depression for the attachment of the column. Posterior side of the cup angularly excavated for the reception of a rather large, lance-shaped, subtriangular anal plate, the opposite side of which is similarly excavated, supporting the anterior radial. First radials almost twice as wide as high, increasing rapidly in width from their lower suture upward. The anterior radial is heptagonal, the two adjoining radials hexagonal. The two posterior first radials are of somewhat different form on account of the triangular or quadrangular anal piece which is intercalated between them, and they are either heptagonal or hexagonal according as this plate is of equal height with them or shorter. The upper side of the first radials is excavated and more or less concave, it supports not only the second primary radials, but also the two secondary ones, and, what is most remarkable, one of the first series of tertiary radials; all of which plates, with 1 × 2 × 20 additional tertiary radials, form part of the calyx. The second primary radial is placed within the concavity of the first plate; it is very minute, sometimes invisible externally, of triangular form, and supporting on each sloping face a single series of bifurcating plates, which rank as secondary radials. These latter meet above the apex of the small second radial, and rest by one side upon the large first radials, while their two upper faces support from 2 to 3 × 20 tertiary radials, or 2 × 4 to each ray. Of these plates, the two outer ones of each ray rest with one side upon the outer extremity of the margin of the first radials, with the outer side against one of the upper sloping faces of the secondary radials, the inner sides meet each other, while their upper faces support a second tertiary radial. The two plates toward the inner ray are narrower, truncate below, resting upon the longer upper face of the secondary radials, and support like the outer plates one or two plates in succession, which in turn support the arms. The radials of the higher orders are almost of equal size, and at least twice as wide as high. There is no interradial within the calyx, and no other anal plate but the one described.[1]

Dome highly elevated, pyramidal, pentagonal in outline. The angles which are radial, are excavated for the attachment of the large radial processes. The sides of the pentagon are the interradial spaces, which seem to have faint grooves, running longitudinally, wherein the arms rest. Four of the interradial spaces are of equal size, the fifth somewhat larger. All five are similarly constructed, and contain three plates in the lower series. The middle or first interradial plate is the larger, its two upper sides forming an angle. The two adjacent plates, as will be explained presently, are representations of radials of a second order. Above these and alternating with them, rests a second series of interradials, composed of two plates, larger than the first, and these meet laterally with corresponding plates of adjacent rays. The upper series, representing the proximal vault pieces, consists of a single plate in four of the spaces, and two slightly smaller ones in that of the posterior side, which all join laterally and form a continuous ring. In a few instances only, there appears to be a small anal plate located between the two smaller proximal plates.

The first radial dome plates are enormously developed in the form of wing-like processes which form the most characteristic feature of the genus. Succeeding these outward, toward the rim, are two small secondary radial dome-plates, one on each side of the lower interradial, and two still smaller plates bifurcating from the last, which are tertiary radial dome plates, but which are rarely observed. Besides these there is a rather large, very peculiar interbrachial plate, beneath the winged first radial. The winged extensions of the first radial dome plate are very variable in form. They are, according to Wetherby, either spatulate, claviform, or cuneiform; in some species thin and knife-like throughout their length; in others thickened and rounded above, and slightly thinner below; in some terminating in thin round edges, in others tapering almost to a point; while still others are bifurcate at the extremities. The monstrous plates, which rise to the full height of the summit, and laterally extending far beyond it, rest chiefly upon the surface of the vault, within grooves, bordered by elevated ridges along the interradial and proximal dome plates, and only a small portion at the lower end is wedged in between other plates. The ridges continue along the interbrachial plate, which for a plate of that order is unusually large. The interbrachial plates, together with the secondary radials and lower interradials, form the base of the dome.

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[1] In one of Wetherby s specimens which he kindly loaned us, we found a little triangular piece resting upon the anal plate. Whether this is abnormal, or a deviation from the general rule and of specific importance, we are as yet unable to say.

The summit leans somewhat to the posterior side, more especially the upper portion, which in the best specimens consists of a small cone, composed of a number of small plates, which decrease in size upward, leaving a minute anal opening at the upper end of the cone.[1]

In front of the anal opening, and in the radial centre, there is a pentagonal plate which is at once recognized as the central dome plate. To this plate converge not only the radial grooves in which the winged processes rest, but also the smaller grooves within the interradial spaces which receive the arms. These latter pass into the ambulacral or arm openings, which are rather large, and have an upward direction.

The arms are short, simple, gradually diminishing in size upward, extending to the top of the vault, but not beyond it. They are twenty in number, divided by the winged processes into groups of four, each containing two arms of two different rays. They are constructed of two rows of short interlocking joints, moderately convex on the dorsal side. Ambulacral furrows, wide and deep. Pinnules short, stout, composed of five or six joints.

The visceral cavity, as seen from one of Wetherby's specimens, (vertical section) is deeper than would be expected from the form of the body. The basal plates are very thin, while the radials, to the top of the third order, increase rapidly in thickness.

Column slender, round; central perforation small.

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[1] It is very possible that in some of the species the anus is not thus extended into a tube-like cone, but this is the case in *Pterotocrinus depressus* Lyon and Cass. The anal aperture is but rarely observed, being generally covered by the shell of a Gasteropod.

Geological Position, etc.—*Pterotocrinus* is the last survivor of the Platycrinidæ, and occurs only in the Kaskaskia limestone of America.

The following species are known:—

1879. **Pterotocrinus acutus** Wetherby. Journ. Cin. Soc. Nat. Hist. (Oct. No.), p. 1, Pl. 11, figs. 2 a, b, c. Kaskaskia limest. Pulaski Co., Ky.

1879. **Pterotocr. bifurcatus** Wetherby. Journ. Cin. Soc. Nat. Hist. (Oct. No.), p. 3, Pl. 11, figs. 1 a, b, c. Kaskaskia limest. Pulaski Co., Ky.

1857. **Pterotocr. capitalis** Lyon. (**Asterocr. capitalis**). Type of the genus. Ky. Geol. Surv., iii, p. 472, Pl. 3, figs. 1 a–k; Lyon and Cass., 1859, **Pterotocr. capitalis,** Am. Journ. Sci. and Arts, vol. xxix, p. 68. Kaskaskia limest. Crittenden Co., Ky.

1860. **Pterotocr. Chesterensis** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 383; and 1866, Geol. Rep. Ill. ii, p. 292, Pl. 23, figs. 1 a, b, c. Kaskaskia limest. Hardin Co., Ill.

1857. **Pterotocr. coronatus** Lyon (**Asterocr. coronatus**). Ky. Geol. Surv., iii, p. 476, Pl. 1, figs. 1, 1 a. Kaskaskia limest. Crittenden Co., Ky.

1860. **Pterotocr. crassus** Meek and Worth. Proc. Acad. Nat. Sci. Phila. p. 382, and 1866, Geol. Rep. Ill, ii, p. 240, Pl. 23, figs. 2 a, b. Kaskaskia limest. Hardin Co., Ill.

1859. **Pterotocr. depressus** Lyon and Cass. Am. Journ. Sci. and Arts, vol. xxix. p. 68. Kaskaskia limest. Grayson Springs, Ky.

*1858. **Pterotocr. protuberans** Hall. (**Dichocr. protuberans**). Geol. Rep. Iowa, i, Pt. 2, p 689, Pl. 25, fig. 7. Kaskaskia limest. Chester, Ill.

1859. **Pterotocr. pyramidalis** Lyon and Cass. Am. Journ. Sci. and Arts, xxix, p. 69. Kaskaskia limest. Grayson and Edmonson Cos., Ky.

This species is evidently identical with **P. depressus,** and was described from a specimen showing the vault in place of the arms.

1879. **Pterotocr. spatulatus** Wetherby. Journ. Cin. Soc. Nat. Hist. (Oct. No.), p. 4, Pl. 11, figs. 3 a, b, c. Kaskaskia limest. Pulaski Co., Ky.

B. ACTINOCRINIDÆ Roemer and Zittel.

(Amend. Wachsm. and Spr.)

The name Actinocrinidæ was first employed by Roemer in 1855, who arranged under it *Actinocrinus*, *Amphoracrinus*, *Dorycrinus* and *Batocrinus*, genera without underbasals, with three basal plates, and in which the first anal piece extends to the line of the first radials. He placed *Melocrinus* and all genera with four basals and no anal plate within the first radial ring under his Melocrinidæ, not including, however, *Eucalyptocrinus* nor *Ctenocrinus*, which latter, as he supposed, had only three basals. *Periechocrinus* (*Pradocrinus* and *Saccocrinus*), which he thought differed in the anal area, and *Ctenocrinus*, he placed with *Glyptocrinus*—of which the under basals had not been discovered—under the Ctenocrinidæ; while *Carpocrinus* and *Macrostylocrinus* were referred to the Cyathocrinidæ.

Zittel amended Actinocripidæ by admitting *Periechocrinus*, *Eretmocrinus*, *Alloprosallocrinus*, *Strotocrinus*, *Steganocrinus*. *Agaricocrinus* and *Megistocrinus*, partly, however, as subgenera of *Actinocrinus*. He, like Roemer and Angelin, separated the genera with four basals, and ranged *Stelidiocrinus* and *Harmocrinus*, which have five basal pieces, under a distinct family. Zittel further excluded *Carpocrinus*, *Habrocrinus* and *Desmidocrinus*, species with single arm joints, for which he proposed the name Carpocrinidæ, and he placed under the Dimerocrinidæ *Marcostylocrinus* and *Dolatocrinus*, genera with three basals and no anal plate in line with the first radials, and among these he admitted *Cytocrinus*, which we have ascertained has four and not three basals, and *Dimerocrinus*, which has underbasals.

The fact that in those classifications the least mistake or misconception as to the number of the basals, a diversity in the position or distribution of the anal plates, or a slight variation in the form of the arm joints, throws the genus from one family into another, is in itself sufficient proof, that the divisions are arbitrary and artificial. A classification based upon fossils should be as simple as possible, resting upon a broad basis, and the family divisions should express important and evident structural features, and be not dependent upon such trifling variations as the number of basal plates, etc.

We place among the Actinocrinidæ all genera of the Sphæroidocrinidæ, which are constructed of basals (without underbasals); 3 × 5—rarely 2 × 5—primary radials, all forming a part of the calyx; one or more higher orders of radials, with at least one, but generally several additional interradial pieces beneath the arm regions; a vault composed of a large number of heavy plates in contact with each other; and we include species both with single and double jointed arms.

For greater convenience of study we arrange the genera under six sections.

a. Stelidiocrinites: The simplest form of the sub-family. General symmetry more or less perfectly pentahedral; calyx low; basals five or three; second radials short; anal and interradial area scarcely distinct; arms single or double jointed.

b. Agaricocrinites: Symmetry decidedly bilateral; calyx low;

basals three; second primary radials quadrangular and short; the first anal plate in line with the first radials; arms heavy, simple, composed of single or double joints.

c. Melocrinites: Symmetry more or less uniformly pentahedral; calyx large; basals four or three; second radials comparatively high and generally hexagonal; interradials numerous; anal side but little distinct and its plates not extending to the line of the first radials; interaxillaries sometimes present; arms given off laterally; columnar canal pentalobate and rather large.

d. Periechocrinites: General symmetry bilateral; calyx very large; basals four or three; second radials large, frequently higher than wide; interradials and interaxillaries numerous; first anal plate in line with the first radials, succeeded by three plates in the second series; arms branching; column large, and with a wide pentalobate canal.

e. Actinocrinites: Symmetry slightly bilateral; calyx large; basals three; second primary radials nearly as high as wide, hexagonal; higher orders of radials numerous, composed of one series of plates each, which give off the arms alternately from opposite sides; interradials in two rows; the first anal plate enclosed between the first radials, supporting only two plates in the second series; interaxillaries generally present; arms long, double jointed.

f. Batocrinites; symmetry more or less bilateral; calyx large; basals three; second radials short, linear; higher orders of radials rarely exceeding three, the plates of the last order touching laterally all around the body, except sometimes over the anal area. Interradials few; interaxillaries absent; first anal plate in line with the first radials, second series composed of three plates; arms short, double jointed.

These groups are founded upon the construction of the anal area, in connection with the form and arrangement of the radial plates and the arms. A division merely based upon the construction of the anal area, as we have adopted among Platycrinidæ, would bring together the *Stelidiocrinites* and *Melocrinites* as opposed to the *Agaricocrinites*, *Periechocrinites* and *Batocrinites*, while the *Actinocrinites* would occupy a place somewhat between the two. A separation by means of the second primary radials brings into closer proximity *Stelidiocrinites* and *Agaricocrinites*, in which those plates are short, linear and quadrangular, against the three other sections in which they are comparatively high and hexagonal. An exception is here found in *Dolatocrinus* and *Stereocrinus*, in which the second radials are quadrangular or even absent, and which should perhaps be placed more properly in a group by themselves.

The form of the second radials is no doubt of some importance in the structure of these crinoids. In species in which they are quadrangular and linear, the second and third radials together very often fail to attain the size of the first radial plate. In various cases of *Dolatocrinus*, *Alloprosallocrinus* and *Batocrinus*, the second radials are so small that they are discovered with difficulty, and are not unfrequently in single rays entirely absent. In species in which the plates of the calyx are tuberculous, they are often the only plates which bear no tubercle. All this hints at the conclusion that the second and third radials, which combined take the form of a single bifurcating plate, here take the place of a single plate joined by syzygy, with the epizygial part bearing an arm instead of a pinnule, and that in species which as a rule have only two primary radials, but otherwise agree with some other genus, the joints became perfectly anchylosed. Such was evidently the case with *Dolatocrinus* and *Stereocrinus*, *Eucrinus* and *Anthemocrinus*, *Lecanocrinus* and *Pycnosaccus*. In *Platycrinus*, which also has only two primary radials, the division appears yet frequently in form of a shallow groove at the surface of the plate, where the earlier Platycrinidæ have a regular suture.

In species with more than ten arms, the rays are generally composed of two main divisions, of which each side gives off arms in opposite directions. The only exception is *Steganocrinus sculptus* Hall, in which the ray is undivided (Pl. 18, fig. 3). In this species, the third primary radials, like all succeeding plates (radials of superior orders), take the form of pinnule-bearing plates, which, instead of bifurcating, give off laterally arms in the same manner as the others do pinnules.

This is of interest, as it leads to the conclusion that probably the secondary radials—the distichalia of Müller—made their appearance in the young crinoid in form of a pinnule given off from the radials which at first formed the only arms of the ray.

We have already shown in our general remarks on the family that the higher orders of radials were in the young animal free arm plates, and we have proved by many examples that the arms spring off in exactly the same manner as the pinnules, and they evidently were pinnule-like in their earlier form.

The earliest Actinocrinidæ known to us are found in the Upper Silurian, but the species and even genera which already occur there are so numerous, and show such variety of form, and some of them appear to be so highly developed, that evidently the family had been represented at a much earlier epoch. It is possible that *Schizocrinus* Hall of the Lower Silurian, which is imperfectly known, should be referred to the Actinocrinidæ, but it may have underbasals. In the earlier representatives of this family, the underbasals form the criterion by which alone the Actinocrinidæ and Rhodocrinidæ can be distinguished, and as these plates in the earlier types are very minute, it is often exceedingly difficult to make the separation. In *Glyptocrinus* the underbasals may perhaps be absent in some species, but when visible they are exceedingly rudimentary. Species without them might be referred, almost with the same propriety to the Actinocrinidæ, and indeed, they have a remarkably close resemblance to species of *Melocrinus* and *Mariacrinus* with four basal plates. A similar relation exists between *Dimerocrinus* and *Stelidiocrinus*, *Glyptaster* and *Periechocrinus*, which can be distinguished only by the underbasals.

In *Stelidiocrinus* and *Melocrinus*, we recognize representatives of two of the four divisions of the Actinocrinidæ which occur in the Upper Silurian. The two differ essentially in the relative size of their body, and in the number and distribution of the plates in the calyx, but agree in the arrangement of their anal area. *Carpocrinus* and *Periechocrinus*, which belong to the same geological age, are separated by the very same characters, the former agreeing closely with *Stelidiocrinus*, the latter with *Melocrinus*, but both are readily distinguished by having a special anal plate in line with the first radials.

The *Stelidiocrinites* disappear in the Upper Silurian, where they are first known. The *Periechocrinites* and *Agaricocrinites* survived to the Subcarboniferous, the former to the Burlington, the latter to the Keokuk epoch. The *Melocrinites* became extinct in the Devonian. The *Actinocrinites* and *Batocrinites* are restricted almost exclusively to the Subcarboniferous; a few aberrant forms are known from the Hamilton group. The *Actinocrinidæ* became altogether extinct after the age of the Warsaw limestone.

We arrange the six sections as follows :—

a. STELIDIOCRINITES.

1. *Briarocrinus* Angelin.
2. *Stelidiocrinus* Angelin.
3. *Patelliocrinus* Angelin.
4. *Macrostylocrinus* Hall.
   Subgenus *Centrocrinus* Wachsmuth & Springer.

b. AGARICOCRINITES.

5. *Carpocrinus* Müller.
   Subgenus *Desmidocrinus* Angelin.
6. *Agaricocrinus* Troost.
   Subgenus *Alloprosallocrinus* Lyon & Casseday.

c. MELOCRINITES.

7. *Mariacrinus* Wachsm. & Spr.
8. *Technocrinus* Hall.
9. *Melocrinus* Goldfuss.
10. *Scyphocrinus* Zenker.
11. *Dolatocrinus* Lyon.
    Subgenus *Stereocrinus* Barris.

d. PERIECHOCRINITES.

12. *Periechocrinus* Austin.
13. *Abacocrinus* Angelin.
14. *Megistocrinus* Owen & Shumard.

e. ACTINOCRINITES.

15. *Actinocrinus* Miller.
16. *Teleiocrinus* Wachsm. & Spr.
17. *Steganocrinus* Meek & Worthen.
18. *Amphoracrinus* Austin.
19. *Physetocrinus* Meek & Worthen.
20. *Strotocrinus* Meek & Worthen.
21. *Gennæocrinus* Wachsm. & Spr.

f. BATOCRINITES.

22. *Batocrinus* Casseday.
23. *Eretmocrinus* Lyon & Casseday.
24. *Dorycrinus* F. Roemer.

a. STELIDIOCRINITES.

1. **BRIAROCRINUS** Angelin.

1878. Angelin. Iconog. Crin. Suec., p. 1.
1879. Zittel. Handb. der Palæont., i, p. 367.

Briarocrinus represents the simplest conceivable form that can be admitted among the Actinocrinidæ. It has two interradial plates, and these, in the typical species, are situated above the line of the third primary radials. Its perfectly straight arm joints suggest an immature crinoidal structure.

B. angustus Angl. is too plainly distinct from *B. inflatus* Angl., in the construction of the plates of the calyx, and particularly in the interradial portions, to be admitted into the same genus, and as it agrees with no other, we should propose it as the type of a new genus, if we had before us specimens instead of a single figure. For want of material, we leave it here for the present.

Angelin and Zittel arranged *Briarocrinus* under a separate family, in which the latter includes *Culicocrinus*. It is true that *B. inflatus* deviates from all other Actinocrinidæ in its interradial parts, but it differs fully as much from *Culicocrinus* in the same characters, the latter being decidedly a Platycrinoid. *Briarocrinus*, in our opinion, leans rather toward the Ichthyocrinidæ, with which it agrees in the alternate arrangement of the radial plates, but it has evidently not their pliant body.

Generic Diagnosis.—Calyx cup-shaped; symmetry pentahedral, with some inequality in the sides due to irregularities in the radial series.

Basals three, usually large, two of them equal and larger than the third. Primary radials 3 × 5, wider than high, joining laterally. The third is a bifurcating plate with very obtuse upper angles, supporting in almost vertical succession 3 × 10 secondary radials, which are half the width of the primary radials, and interlock up to the second plate; the third pair being separated by a small axillary piece. The radials are generally irregular in form, even those of a like order or series are differing markedly among each other in height and width. In some of the rays, the first radials are larger by half than in others, and in these the second radials are much higher and generally wider; in others only one side of the plate is lower, a construction producing a sort of alternate arrangement of the plates, which extends up to the secondary radials. The plates of this second order are separated from each other, laterally, by a line of two small interradial pieces, which in alternate rays, respectively, rest upon the upper corners of two of the third primaries, or upon the upper sloping side of the first secondary radial.

Arms ten, supported directly upon the secondary radials; heavy, simple, composed of single transverse round joints, with parallel sutures and long pinnules.

Posterior or anal side, so far as known, not distinct.

Column round.

In the absence of interradial plates between the primary radials, and in the alternate arrangement of the latter, this genus differs from all others of the family.

Geological Position, etc.—Found thus far only in the Upper Silurian of Sweden.

1878. **Briarocrinus inflatus** Angelin. Iconogr. Crin. Suec., p. 1, Pl. 10, fig. 23. Upper Silur. Gothland, Sweden.
(?] 1878. **Briarocr. angustus** Angelin. Iconogr. Crin. Suec., p. 1, Pl. 10, fig. 22. Upper Silur. Gothland, Sweden.

2. STELIDIOCRINUS Angelin.

(Amend. Wachsmuth and Springer.)

1878. Angelin. Iconogr. Crin. Suec., p. 21.
1879. Zittel. Handb. der Palæont., i, p. 345.
Syn. *Harmocrinus* Angelin. Iconogr. Crin. Suec., p. 22.

We are obliged to include Angelin's genus *Harmocrinus* in *Stelidiocrinus*. A few additional interradial or interaxillary plates do not alone warrant a generic or even subgeneric separation. According to Angelin and Zittel, *Stelidiocrinus* and *Harmocrinus*, with Hall's *Schizocrinus*, form a distinct family.

The genus now under consideration is in more than one respect an interesting form with reference to the Palæontologic history of the Crinoids. It is the only genus of the Actinocrinidæ which has five basal plates, none of them being anchylosed, and as this is one of their earliest representatives, there can be little doubt that the basals in this family, whether composed of a single piece or of three or four, were derived originally from five. The relations also between this genus and *Dimerocrinus* of the Rhodocrinidæ are so close, that it may be asked whether the presence of underbasals, which form the only distinction, should be considered of more than generic importance. It shows, at all events, the very close relations that exist between the two sub-families. There is also to be seen within the limits of this genus, a modification of the arms from interlocking single joints to a double series of plates.

Generic Diagnosis.—Body small. Calyx subturbinate or subovate, without surface ornamentation; radial plates prominently elevated above the interradial areas, but not producing sharp carinæ.

Basals five, equal, quadrangular, upper angles acute. Primary radials 3 × 5; the first large, wider than high, lunate, hexagonal; the second quadrangular, shorter and much narrower; the third pentagonal, almost as wide but not as high as the first. Secondary radials 2 to 4 × 10, wider than high, supporting in direct line a single rather stout arm or ten in all. It is possible that the number of secondary radials varies with age, and that there are four in the adult.

Arms composed either of a single row of cuneiform plates slightly interlocking, or of two rows of short plates alternately arranged.

Interradials four to eight; the first large, resting upon the sloping sides of the first radials and between the second and third of adjacent rays, the succeeding plates much smaller and connecting with the vault pieces. Posterior area wider; the first anal piece in line with the first interradials, the second and third ranges consisting of two instead of three pieces. Anus in form of a simple lateral opening similar to *Dorycrinus.*

Vault compressed, composed almost exclusively of the apical dome plates, which are unusually large. In *Stelidiocr. capitulum*, the vault is constructed of only twenty-three pieces, the smallest possible number of which a species with ten arms can be composed in accordance with the rule prevailing among these crinoids. It consists of the central piece, the six proximal plates, a single anal, and three radials to each ray. The two secondary radials of the dome are exceedingly small, while the proximal vault pieces occupy almost three-fourths of the entire summit.

Column round, articulating faces crenulated.

The genus resembles *Patelliocrinus*, but differs from it and all similar genera in the number of basal plates.

Geological Position, etc.—Restricted to the Upper Silurian of Europe.

We recognize the following species.—

1878. **Stelidiocrinus capitulum** Angelin. Type of the genus. Iconogr. Crin. Suec., p. 21, Pl. 17, figs. 5a-g. Upper Silur. Gothland, Sweden.

*1878. **Stelidiocr. longimanus** Angel. (**Harmocr. longimanus**). Iconogr. Crin. Suec., Pl. 21, figs. 6, 7. Upper Silur. Gothland, Sweden.

1878. **Stelidiocr. lævis** Angelin. Iconogr. Crin. Suec., p. 21, Pl. 15, figs. 20, 20a; also Pl. 27, figs, 3, 3a, (not Pl. 28, figs. 7, a, b). Upper Silur. Gothland, Sweden.

Angelin's figures are not so reliable as could be wished. Those of *S. lævis* on Pl. 15 have single jointed arms, while those on Pl. 27 have a double series of plates. It may be possible that the former are taken from a young specimen. The figures 7 a b, on Pl. 28 are evidently referred to this genus by oversight, as they are clearly of *Desmidocrinus macrodactylus.*

1878. (?) **Stelidiocr. ovalis** Angelin. Iconogr. Crin. Suec., p. 21, Pl. 19, fig. 6. Upper Silur. Gothland, Sweden.

This species differs from *Stelidiocrinus* in several important points and ought to be separated from it. To judge from the construction of the anal plates it should be removed to the Agaricocrinites, but it is possible, if the figure is correct, and the interradial plates, as there represented, extend to the basals in all five areae, that it possesses underbasals, and properly belongs to the Rhodocrinidæ. We refrain from proposing new generic names for these straggling forms, as we cannot altogether depend upon the figures, and we hope they will be taken up by investigators more familiar with these types, and who have access to the specimens.

3. PATELLIOCRINUS Angelin.

1878. Angelin. Iconogr. Crin. Suec., p. 1.
1879. Zittel. Handb. der Palæont, p. 368.

Several of these species referred by Angelin to this genus belong, in our opinion, to very distinct genera. His *Pat. duplicatus* has not only four arms to the ray, but as we judge from the shape and size of the basals, evidently had underbasals; also the first anal plate is in line with the first radials, while in all other species of *Patelliocrinus* those plates are ranged with the second radials. In *Pat. fulminatus* the calyx is but imperfectly preserved, but we judge from what is exposed, that this species was closely allied to another figured in Iconogr., Pl. 18, fig. 16, as *Melocr. Volborthi*.[1] Both species have branching arms, unlike *Patelliocrinus*, and are probably generically identical. We should propose for them a new genus, if we had more perfect figures for description.

Zittel made *Patelliocrinus* a synonym of *Dimerocrinus* Phill., which, however, has five basals instead of three, and underbasals. In his classification he arranges *Dimerocrinus* with *Dolatocrinus*, *Cytocrinus* with *Macrostylocrinus*, and all under the Patelliocrinidæ.

Patelliocrinus is one of those genera in which the arms as a rule are neither single- nor double-jointed, and sometimes scarcely interlocking at all, resembling herein *Eupachycrinus* and *Erisocrinus* of the Cyathocrinidæ.

Generic Diagnosis—General form oblong. Calyx patelliform; symmetry almost perfectly equilateral.

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[1] We take it that *Melocr. Volborthi* is represented by Pl. 7, figs. 7 to 11, which is an entirely different thing from Pl. 18, fig. 16.

Basals three, unequal; two of them pentagonal, the third smaller by one-half, and quadrangular. Primary radials 3 × 5; the first ones forming laterally a continuous ring, larger than those succeeding, heptagonal, the lateral margins very long; the second quadrangular, wider than high; the third axillary of medium size, upper angle obtuse. Secondary radials 2 × 10, which directly support the arms, or sometimes the second plate is the bifurcating piece, and supports upon the inner and wider sloping side an arm; upon the smaller side an extraordinary large pinnule, which takes the direction of the arm, being more erect than the succeeding pinnules, and twice as heavy. The arms are large, heavy at the base, and towards the tips gradually tapering into a sharp point. The proximal arm plates are large, resembling secondary radials, and like them are decreasing in height upward; succeeding joints cuneate, gradually passing into two rows of interlocking pieces. In *P. pinnulatus* they pass scarcely beyond the earliest stage of interlocking arms; in *P. chiastodactylus* the arms remain single-jointed throughout, but the joints are strongly cuneiform. Pinnules long, rather strong, and composed of single joints.

Interradials three, the first very large, with a small one in the second, and a still smaller triangular one in the third series, the latter abutting against the large proximal arm-like pinnules. There are some species with five interradials, having two plates in the second, and two in the third range. Anal side not structurally distinct.

Vault unknown, anal aperture apparently lateral.

Column cylindrical.

This genus, in its general habitus, resembles *Agaricocrinus*, particularly its earlier and smaller species; but the two genera are very distinct in the construction of the anal area.

Geological Position, etc.—*Patelliocrinus*, so far as now known, is confined to the Upper Silurian of Europe.

We recognize the following species:—

1878. **Patelliocrinus chiastodactylus** Angelin. Icongr. Crin. Suec., p. 1, Pl. 19, fig. 12. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. interradius** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 22, fig. 10. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. leptodactylus** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 16, figs. 26, 31. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. pachydactylus** Angelin (type of the genus). Iconogr. Crin. Suec., p. 1, Pl. 16, figs. 24, 25. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. pinnulatus** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 24, fig. 5 and Pl. 26, fig. 18. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. plumulosus** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 22, figs. 8, 9. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. punctuosus** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 23, fig. 26. Upper Silur. Gothland, Sweden.

The two following species, which were described by Angelin under this genus, cannot be brought with satisfaction under this or any other established generic form.

(?) 1878. **Patelliocr. duplicatus** Angelin. Iconogr. Crin. Suec., p. 1, Pl. 19, fig. 5. Upper Silur. Gothland, Sweden.

(?) **Patelliocr. fulminatus** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 26, figs. 14, 14 a b. Upper Silur. Gothland, Sweden.

4. MACROSTYLOCRINUS Hall.

1852. Hall. Paleont., New York, vol. ii, p. 203.
1863. Hall. Trans. Albany Inst., p. 207.
1879. Hall. 28th Rep. New York St. Cab. Nat. Hist. (2d ed.), p. 129.
1879. Zittel. Handb. der Paleont., p. 368.

This genus has been frequently identified with *Ctenocrinus* Bronn,[1] and with *Cytocrinus* Roemer.[2]

It has been shown, however, by Schultze (Mon. Echin. Eifel Kalk, p. 62), that *Ctenocrinus* has four, and not three or five basal plates as supposed by previous authors,[3] and we can state positively, that we have also found four instead of three in *Cytocrinus lævis* Roemer. This discovery leaves no doubt that the two genera are identical with each other, as well as with *Melocrinus* Goldfuss, but distinct from *Macrostylocrinus*.

In the construction of the calyx, *Macrostylocrinus* resembles the preceding genus, the two varying only in the proportionate size of the different plates; but this gives them a totally different appearance.

In its general habitus *Macrostylocrinus* approaches the *Periechocrinites*, while *Patelliocrinus* is a step in the direction of the *Agaricocrinites*. We are sure that the vault of *Macrostylocrinus* when found, will prove to be constructed of a great number of minute pieces, while we shall expect in *Patelliocrinus* a summit more like that of *Stelidiocrinus*, which is composed of but few and large plates.

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[1] Bronn's Jahrbuch, 1840, p. 252.

[2] Silur. Fauna, West Tenn., p. 46.

[3] Compare our notes on *Melocrinus*.

Zittel places *Macrostylocrinus* with *Dimerocrinus*, *Dolatocrinus* and *Cytocrinus* under the Dimerocrinidæ.

Generic Diagnosis.—Calyx subglobose to urn-shaped, as high or higher than wide; surface granulose-striate, or only granulose; the five sides almost perfectly equilateral.

Basals three, comparatively large, forming a more or less shallow cup, two of them equal and pentagonal, the third smaller by half and quadrangular. Primary radials 3 × 5; the first series large; the second hexagonal, less than half, sometimes scarcely one-third the size of the first, wider than high; the third pentagonal, smaller than the second, supporting one or more secondary radials in a direct line, which support the arms. Arms only known in *M. ornatus*, where they are long, simple, composed at the base of a single row of alternately arranged wedge-form pieces, which, from the sixth or seventh plate up, interlock with each other, and gradually pass into a double series.

Interradial area more or less depressed, deeper between the arm-bases, in consequence of which the radial portions of the calyx, and especially the secondary radials, are somewhat lobed, which is characteristic of this genus, and which distinguishes it readily from the related form *Patelliocrinus*. First interradial large, hexagonal, supporting two small plates in the second series. Anal area slightly wider, and with three plates in place of two in the second range.

Geological Position, etc.—*Macrostylocrinus* is confined to the Niagara group of America.

The following species are known:

*1864. **Macrostylocrinus Meeki** Lyon. (**Actinocr. Meeki**). Proc. Acad. Nat. Sci. Phila., p. 411, Pl. 4, figs. 4 a b. Niagara gr. Jefferson Co., Ky.

Syn. **Cyathocr. fasciatus** Hall. 28th Rep. New York St. Cab. Nat. Hist. (1st ed.), Pl. 13, figs. 5 and 6; Wachsm. and Spr. Revision i, p. 85. Waldron, Ind.

Syn. **Macrostylocrinus fasciatus** Hall. Ib. (2d edit.), p. 130.

1852. **Macrostylocr. ornatus** Hall (Type of the genus). Paleont., New York, ii, p. 204, Pl. 46, figs. 4 a-g. Niagara gr. Lockport, N. Y.

1863. **Macrostylocr. striatus** Hall. Trans. Albany Inst., iv, p. 207; also 20th Rep. New York St. Cab. Nat. Hist., 1867, p. 327, Pl. 10, fig. 7. Niagara gr. Waldron, Ind., and Racine, Wis.

Subgenus **CENTROCRINUS** Wachsm. and Spr.

This genus should not be confounded with *Centrocrinus* Austin,[1] which in 1843, was proposed to distinguish a certain form of *Platycrinus*, but based altogether upon conjecture and incorrect observation.

The generic form now suggested embraces at present only two species, Lyon's *Actinocrinus pentaspinus* and his *A. multicornus*, of which we propose the former as the type. The two differ from *Actinocrinus* essentially in the construction of the anal area, having no plate in line with the first radials. The nearest allied genus, and under which we place it subgenerically, is *Macrostylocrinus*, but this has three anal plates in the second series, in place of two, while in *Centrocrinus* the posterior side is not in any way distinct from the other four. The spiniferous form of some of the body plates has suggested the name.

Generic Diagnosis.—Calyx subcylindrical; symmetry perfectly pentahedral; the principal plates produced into spines; the calyx in its lower portions almost resembling *Platycrinus*, owing to the form and size of basals and first radials.

Basal disk large, pentagonal, composed of three unequal pieces, two of them pentangular, and twice the size of the third, which is quadrangular.

Primary radials 3 × 5; the first very large and spiniferous; second radials much smaller than the first, short and quadrangular or nearly so; third radials pentangular, sometimes triangular, as short as—and occasionally narrower—than the second. Secondary radials 1 × 10, bent abruptly outward and supporting the arms. There are, so far as known, two arms to each ray.

Interradials four to five; the first large and frequently spiniferous, deeply inserted between the first radials, in which the upper lateral margins are exceptionally long; second series composed of two plates, much smaller than the first; third series consisting of one or two plates, located between the arm bases. Anal area not distinct. Construction of vault and arms unknown.

Column round, central canal round.

Geological Position, etc.—Only known from the Devonian of America.

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[1] Mon. Rec. and Foss. Crin., p. 6, proposed for species of *Platycrinus* "with central valvate unobtrusive mouths, or mouths capable of being withdrawn into the visceral cup."

*1860. **Centrocr. multicornus** Lyon (**Actinocr. multicornus**). Trans. Amer. Philos. Soc., vol. 13, p. 455, Pl. 27, fig. e; also Hall, Paleont. N. Y., vol. v, Pt. ii, p. 6, (advance sheets 1878). Nucleocrinus bed. Falls of the Ohio.

*1860. **Centrocr. pentaspinus** Lyon (**Actinocr. pentaspinus**). Type of the subgenus. Trans. Amer. Philos. Soc., vol. 13, p. 453, Pl. 27, figs. d, d 1; also Hall, Paleont. N. Y., vol. v, Pt. ii, p. 6, (advance sheet). Nucleocrinus bed. Falls of the Ohio.

b. AGARICOCRINITES.

5. CARPOCRINUS Müller.

(Amend. Wachsm. and Spr.)

1841. Müller. Monatsb. Berl. Akad. Wissensch., i, p. 208.
1855. Müller. Verhandl. naturh. Verein, xii, p. 19.
1855. F. Roemer. Lethæa Geogn. (Ausg. 3), p. 237.
1857. Pictét. Traité de Paléont., iv, p. 328.
1879. Zittel. Handb. d. Palæont, i, p. 19.
Syn. *Phoenicocrinus* Aust. 1843, Ann. and Mag. Nat. Hist., xi, p. 205.
Syn. *Abracrinus* D'Orb. 1850, Prodr. de Paléont., i, p. 47. (Not Ibid. p. 156); also Course élém. de Paléont., ii, p. 144.
Syn. *Habrocrinus* Angelin, 1878, Iconog. Crin. Suec., p. 3.
Syn. *Pionocrinus* Angelin. Ibid., p. 4.

Angelin and the two Austins, in proposing their genera *Pionocrinus* and *Phoenicocrinus*, were evidently not acquainted with the genus *Carpocrinus*, which had previously been described by Müller. Under *Carpocrinus*, Müller placed *Actinocrinus simplex* and *A. expansus* Phill., but as the two species represent different generic forms, as a rule, the first becomes the type of the genus, and *C. simplex* has been recognized as such in 1855 by Roemer. Neither can we accept, not even subgenerically, *Habrocrinus* (*Abracrinus*) D'Orbigny, which differs from *Pionocrinus* solely in having a few more interradial plates. Closely allied is also *Desmidocrinus* Angelin, which, however, has an additional arm to each ray, with slight deviations in the arm-structure. Whether this is sufficient for a separation from *Carpocrinus*, we do not wish to decide, but it should clearly be no more than subgeneric.

Pictet places *Carpocrinus* with *Forbesiocrinus*, *Taxocrinus*, *Graphiocrinus*, *Lyriocrinus* and *Scyphocrinus* under the *Carpocriniens;* while D'Orbigny and Roemer connect it with the Cyathocrinidæ. Austin combines *Phoenicocrinus* with *Dimerocrinus* and *Tetramerocrinus* under his Merocrinidæ.

Zittel unites *Habrocrinus*, *Carpocrinus*, *Desmidocrinus* and *Leptocrinus* under Carpocrinidæ.

The pinnules in this genus are exceedingly interesting. In some of the species (compare Angelin's figures), we find toward the interradial side the proximal pinnule much larger. It is given off from a second secondary radial, which is converted into a regular bifurcating plate; it stands more erect than the other pinnules, its lower portions embraced within the body walls, its upper and free parts following the direction of the arms. The construction is such that we cannot doubt these large pinnules form a link between arms and pinnules, which finally in *Desmidocrinus* became transformed into regular arms.

Generic Diagnosis.—General form oblong; calyx short, cyathiform; symmetry bilateral

Basals three, short; two of them equal, the third smaller by one-half. Primary radials 3×5; the first larger than the other two; the second short, quadrangular or hexagonal; the third axillary giving off two, rarely 3 × 10 secondary radials. The latter are rounded at the dorsal side, in form almost resembling arm-joints, but larger, especially higher. The secondary radials support directly the arms, of which there are ten to the entire individual, and these remain simple throughout.

The arms are long, heavy, cylindrical, tapering at their tips, and are composed of short single joints, with parallel sutures. Pinnules long, thread-like, composed of a great number of joints.

Interradials from two to three in two series; the first plate large, the upper series generally very small and indistinct. Some of the larger species have a third series with their plates decreasing in size upward.

Anal area considerably wider, and composed of many more plates. The first anal plate in line with the first radials, and fully as large and even larger. There are three plates in the second series, somewhat smaller than those of the first, and generally three in each succeeding series, all arranged in longitudinal rows.

Interaxillary plates from none in the very small species, to one or three in larger ones.

Vault only partly known. In *Carpocrinus ornatus* (Iconogr. Crin., Pl. 27, fig. 5) it seems to have been composed of a large number of plates, among which the apical dome plates are easily distinguished by their larger size: radial portions covered by two rows of low transversed pieces; interpalmar fields paved by somewhat larger and elongate plates.

Column cylindrical, strong.

Carpocrinus differs from all preceding genera in having a spherical anal plate in line with the first radials, and from *Agaricocrinus* in having single arm joints.

Geological Position, etc.—From the Upper Silurian of England and Sweden.

We place here the following species:

*1878. **Carpocrinus affinis** Angelin (**Pionocr. affinis.**) Iconogr. Crin. Suec., p. 5, Pl. 22, fig. 7. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. annulatus** Angel. (**Habrocr. annulatus.**) Iconogr. Crin. Suec., p. 4, Pl. 22, fig. 15. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. cariosolus** Angel. (**Habrocr. cariosolus.**) Iconogr. Crin. Suec., p. 3, Pl. 3, figs. 7, 7 a. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. comptus** Angel. (**Habrocr. comptus.**) Iconogr. Crin. Suec., p. 4, Pl. 22, fig. 13. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. decadactylus** Angel. (**Habrocr. decadactylus.**) Iconogr. Crin. Suec., p. 4, Pl. 15, figs. 18, 19. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. elongatulus** Angel. (**Pionocr. elongatulus.**) Iconogr. Crin. Suec., p. 5, Pl. 22, figs. 16, 17. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. farctus** Angel. (**Pionocr. farctus.**) Iconogr. Crin. Suec., p. 5, Pl. 16, fig. 23, and Pl. 22, figs. 5, 6. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. grandis** Angel. (**Habrocr. grandis.**) Iconogr. Crin. Suec., p. 4, Pl. 26, fig. 10. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. granulatus** Angel. (**Habrocr. granulatus.**) Iconogr. Crin. Suec., p. 4, Pl. 19, figs. 13, 13 a. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. lævis** Angel. (**Habrocr. lævis**) Iconogr. Crin. Suec., p. 4, Pl. 19, figs. 21, a, b. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. longimanus** Angel. (**Harbrocr. longimanus.**) Iconogr. Crin. Suec., p. 4, Pl. 22, figs. 11, 12. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. ornatissimus** Angelin. (**Habrocr. ornatissimus.**) Iconogr. Crin. Suec., p. 4, Pl. 6, fig. 9. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. ornatus** Angel. (**Habrocr. ornatus.**) Iconogr. Crin. Suec., p. 4, Pl. 21, figs. 19, 20 and Pl. 26, figs. 11, 12 and Pl. 27, fig. 5. Upper Silur. Gothland, Sweden.

Figs. 12 a, b, on Pl. 26, represent the convoluted digestive organ of this species. Its lateral sides are enclosed by a delicate intervisceral network of pentangular outline. A similar plexus has been observed in Subcarboniferous genera, but always parallel with the walls of the body.

*1879. **Carpocr. pinnulatus** Angel. (**Habrocr. pinnulatus.**) Iconogr. Crin. Suec., p. 4, Pl. 22, fig. 14. Upper Silur. Gothland, Sweden.

This species differs from the typical form by having in two rays an additional arm.

*1878. **Carpocr. pulchellus** Angel. (**Pionocr. pulchellus.**) Iconogr. Crin. Suec., p. 5, pl. 3, figs. 9, 9 a. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. robustus** Angel. (**Habrocr. robustus.**) Iconogr. Crin. Suec., p. 4, pl. 22, fig. 19. Upper Silurian. Gothland, Sweden.

1839. **Carpocr. simplex** Phill. (**Actinocr, simplex.**) Apud Murchison, Silur. Syst., p. 673, Pl. 18, fig. 8; Austin, 1843, **Phoenicocrinites simplex,** Ann. and Mag. Nat. Hist., xi, p. 2C5; D'Orbigny, 1850, **Abracrinus simplex,** Prodr. Paleont., i, p. 47; Roemer, 1855. **Carpocrinus simplex,** Lethæa Geogn, (Ausg. 3), p. 237; Salter, 1870, **Taxocr. simplex,** Cat. Geol. Mus. Cambr., p. 125; Angelin, 1878, **Pionocr. simplex,** Iconogr. Crin. Suec., p. 5, pl. 15, 15 a. Dudley, England and Gothland, Sweden.

Syn. (?) **Actinocr. tesseracontadactylus,** Hisinger, 1837, (not Goldf.), Lethæa Suecia, p. 90, Pl. 35, figs. 4, a-b; D'Orbigny, 1850. **Ichthyocr. tesseracontadactylus,** Prodr. Paléont. i, p. 46; Salter, 1847, **Cyathocr. tesseracontadactylus,** Murchison's Siluria, (ed. iv), Pl. 14, fig. 4. (We follow Angelin in placing this species a synonym under **Carpocrinus simplex.**)

*1878. **Carpocr. tenuis** Angel. (**Habrocr. tenuis,**) Iconogr. Crin. Suec., p. 4, Pl. 26, figs, 9, 9 a. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. umbonatus** Angel. (**Habrocr. umbonatus.**) Iconogr. Crin. Suec., p. 4, Pl. 26, figs 13, 13 a. Upper Silur. Gothland, Sweden.

Subgenus **DESMIDOCRINUS** Angelin.

1878. Angelin. Iconogr. Crin. Suec., p. 5.

General form oblong to subovoid. Calyx short, saucer- or cup-shaped; symmetry bilateral.

Basals three, small, scarcely projecting laterally. Radials 3 × 5; the first large, polygonal; the second short, linear; the third transverse, pentagonal. Secondary radials 2 × 10, one side of each ray bifurcating again giving off two arms, the other a single one.

In *D. pentadactylus* both halves branch again, thus making three arms to one half, and two arms to the other half division, or five arms to the ray, and twenty-five to the individual.

Arms long, heavy, cylindrical, composed of very short joints, which sometimes become wedge-form and almost interlocking. Pinnules very long, largely articulated.

Interradial and anal plates not differing from *Carpocrinus.*

Column strong, round, composed of alternate large and smaller joints; central perforation pentagonal.

The subgenus *Desmidocrinus* differs from the typical form in the greater number of arms, and that these are given off unequally from the ray, also in having somewhat longer arms with shorter joints.

Geological Position, etc.—Only found in the Upper Silurian of Europe. Angelin refers to it the following species:

1878. **Desmidocrinus heterodactylus** Angel. Iconogr. Crin Suec., p. 5. Pl. 16, 16 a, Upper Silur. Gothland, Sweden.

1878. **Desmidocr. macrodactylus** Angel. Iconogr. Crin. Suec., p. 5, Pl. 16, figs. 20, 21. Upper Silur. Gothland, Sweden.
1878. **Desmidocr. pentadactylus** Angel. Iconogr. Crin. Suec., p. 5, Pl. 16, figs. 15, 22. Upper Silur. Gothland, Sweden.
1878. **Desmidocr. tridactylus** Angel. Iconogr. Crin. Suec., p. 5, Pl. 16, figs. 4, 4 a. Gothland, Sweden. (Probably identical with *D. macrodactylus.*)

6. AGARICOCRINUS Troost.

1850. Troost. List. Crin. Tenn. (Proc. Amer. Association).
1858. Hall (Subgenus of *Actinocr.*). Geol. Rep. Iowa, i, Pt. ii, p. 560.
1866. Shumard (Subg. of *Actinocr.*). Cat. Pal. Foss., Pt. i, p. 350.
1873. Meek and Worthen. Geol. Rep. Ill., v, p. 397.
1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 350.
Syn. *Amphoracrinus* Roemer (not Austin), 1855. Leth. Geogn. (Ausg. 3), p. 250.
Syn. *Amphoracrinus* Hall (not Austin), 1861. Bost. Jour. Nat. Hist., p. 280.
Syn. *Actinocrinus* Hall (in part), 1858. Geol. Rep. Iowa. i, Pt. ii.

Some authors have confounded *Agaricocrinus* with *Amphoracrinus* Austin, with which it agrees in the depressed form of the calyx and in the elevated dome, but while in *Agaricocrinus* the calyx or its equivalent extends to the secondary radials, that of *Amphoracrinus* is properly composed of few plates, all the upper radials, from the third primary up, being parts of free rays. *Amphoracrinus* differs also in the form of the dome, in the spiniferous proximal vault pieces, in having an anal tube, in the surface ornamentation, and in the arms.

Hall, who first defined Troost's genus *Agaricocrinus*, placed it subgenerically under *Actinocrinus*, and referred to it exclusively species with a broadly truncate or concave dorsal side, leaving all similar types with a convex calyx under *Actinocrinus*. This cannot be sustained, as we find among the species of this group all intermediate gradations in this feature, while at the same time they agree most remarkably in all other important characters. The structure of *Agaricocrinus* is so marked that we do not hesitate to rank it as a distinct genus. The differences in the form of the calyx are modifications in geological succession. Species with convex sides are confined to the Waverly group and to the Burlington limestone; species from the Upper Burlington are truncate below, or slightly convex, rarely concave; while the Keokuk species, without exception, are deeply concave in the basal regions.

We place under *Agaricocrinus*, subgenerically, *Alloprosallo-*

crinus Lyon and Casseday, which agrees with the latter in all essential points, but differs in having an anal tube in place of an opening directly through the vault.

Generic Diagnosis.—General form of the body pyramidal, wider than high; symmetry decidedly bilateral; plates without surface ornamentation. The form of the apical side varies from a shallow basin to an inverted cup, and hence from convex to deeply concave; the concavity sometimes involving the third primary and even partly the secondary radials. Dome surpassing the calyx in height, composed of large nodose or tuberculous plates, which are surrounded by smaller scarcely convex pieces.

Basal disk in form of a hexagon with nearly straight sides, composed of three equal plates, very small, frequently hidden from view by the column, spread out horizontally, and forming a small concavity. Primary radials 3×5; the first comparatively small, hexagonal, the upper lateral sides shorter than the other sides; second radials quadrangular or nearly so, smaller than the first, transversely arranged; third pentagonal, wider than high, larger than either of the others. The latter support upon each of their upper sloping faces a wide but short secondary radial, which is succeeded by still shorter plates which gradually interlock and become regular arm plates. All plates above the third radials project at nearly right angles to the vertical axis, their faces directed laterally. This gives to the apical side, when viewed from the column, a pentalobate outline, and the latter plates appear as parts of the free rays. The plates, however, are wedge-shaped, knife-like toward the inner side, and the ambulacral passages within the body communicate directly with the arm furrows. In species with tertiary radials, and consequently a larger number of arms, the last bifurcation takes place upon the first secondary radials, but generally only upon one side and in the posterior rays. There seems to be one or two undescribed species in which the postero-lateral rays have normally four arms. We have in our possession a specimen from Canton, Ind., in which also the antero-lateral rays have an additional arm.

Arms robust, long, simple, gradually tapering and terminating in a sharp point. They are constructed of two rows of pieces, which are alternately arranged, very wide, exceedingly short and linear. Arm furrows wide but shallow; pinnules slender, thread-like, composed of cylindrical joints covering the arm furrows like a roof.

Interradials three, elongate; the first generally the largest plate of the calyx, much narrower than wide, frequently extending in length to the secondary radials. The two plates in the second series are often as long as the first, but rarely of more than half the width, and hence exceedingly narrow; they rest mainly on the outer edges of the secondary radials, and curving upward rise to the level of the top of the arm bases.

First anal plate higher than the first radials, sustaining upon its upper truncate edge a large plate, and on its lateral oblique sides partially supporting two plates which extend upwards, adjoining the secondary radials; these in turn are followed by a large number of small plates, which are more properly ranked as vault pieces.

Dome high, more or less pyramidal, somewhat inflated toward the posterior side. Apical dome plates very large and prominent, and with rare exceptions tuberculiform. The central piece is the largest plate of the entire body; the six proximal plates somewhat smaller, frequently separated from the central piece by a circlet of small irregular plates, and in old specimens and very large species, occasionally isolated laterally. First radial dome plates very large, the two of the second order small. In rays with three arms, one plate of the latter is large and succeeded by two small ones in a third range. Posterior side of the dome composed of small plates, protruding in a rounded ridge with a depression on either side; anal aperture at the upper part of the vault, directed laterally.

Column round, consisting of joints with rounded margins and intermediate thinner joints.

Geological Position, etc.—*Agaricocrinus* is a strictly Subcarboniferous genus, and is only found in America. It first appears in the Waverly group, attains its maximum in the Upper Burlington, and becomes extinct at the end of the Keokuk period, where it attains enormous dimensions.

We arrange under it the following species:—

1855. **Agaricocrinus americanus** Roemer (**Amphoracr. americanus**). Lethaea. Geogn. (Ausg. 3), p. 250, Pl. 4^1, figs. 15, a, b; Shumard, 1866, **Agaricocr. americanus**, Cat. Pal. Foss. N. Amer., pt. i, p. 351; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 239.

This species is very variable, and has a great vertical range, as well as a wide geographical distribution, being found from the upper portion of the Upper Burlington to the middle part of the Keokuk limestone, and it occurs in rocks of that age in Iowa, Indiana, Illinois, Missouri, Kentucky and Tennessee.

Syn. **Agaricocr. tuberosus** Troost, 1850 (catalogue name); Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 617.

Syn. **Agaricocr. bullatus** Hall. 1858, Geol. Rep. Iowa, i, pt. ii, p. 562, Pl. 9, figs. 11, a, b, c.

Syn. **Agaricocr.** (**Amphoracr.**) **excavatus** Hall. Desc. New Spec. Crin., p. 3; also Bost. Journ. Nat. Hist., p. 282.

Syn. **Agaricocr. nodosus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 167; also Geol. Rep. Illinois, vol. v, p. 387, Pl. 10, fig. 7.

*1858. **Agaricocr. brevis** Hall (**Actinocr. brevis**). Geol. Rep. Iowa, i, pt. ii, p. 567, Pl. 10, figs. 3, a, b. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. corniculus** Hall. Geol. Rep. Iowa, i, pt. ii, p. 566, Pl. 10, figs. 1, a, b, c.

*1860. **Agaricocr. convexus** Hall (**Agaricocr. pentagonus** (**var.**) **convexus**). Supp. Geol. Rep. Iowa, p. 58. Upper Burlington limest. Burlington, Iowa.

This form differs from **A. pentagonus** considerably, and proves to be a good species.

*1864. **Agaricocr. eris** Hall (**Actinocr. eris**). 17th Rep. N. York St. Cab. Nat. Hist., p. 53; also Geol. Rep. Ohio Paleont., ii, p. 164, Pl. 11, figs. 9, 10. Waverly gr. Richfield, Ohio. A variety of **Agaricocr. helice.**

*1861. **Agaricocr. fiscellus** Hall. (**Actinocr. fiscellus**). Desc. New Pal. Crin., p. 2; also Bost. Journ. Nat. Hist., p. 272. Lower Burlington limest. Burlington, Iowa.

Possibly a mere variety of **A. brevis**, having an additional arm in the posterolateral rays.

1860. **Agaricocr. geometricus** Hall. Suppl. Geol. Rep. Iowa, p. 56. Upper Burlington limest. Quincy, Ill.

1861. **Agaricocr. gracilis** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 135. Upper Burlington limest. Burlington, Iowa.

*1864. **Agaricocr. helice** Hall (**Actinocr. helice**). 17th Rep. N. York St. Cab. Nat. Hist., p. 53; also Geol. Rep. Ohio, Paleont., ii, p. 163, Pl. 11, figs. 5–8. Waverly gr. Richfield, Ohio.

1861. **Agaricocr. inflatus** Hall (**Agaricocr.—Amphoracr.—inflatus,** not **Amphoracr. inflatus** Hall). Descr. New Pal. Crin., p. 4; also Bost. Journ. Nat Hist., p. 284. Upper Burlington limest. Burlington, Iowa.

1861. **Agaricocr. ornotrema** Hall (**Agaricocr.—Amphoracr.—ornotrema**). Desc. New Spec. Crin., p. 3. Upper Burlington limest. Burlington, Iowa.

Syn. **Agaricocr.—Amphoracr.—bellatrema** Hall. Bost. Journ. Nat. Hist., 1861, p. 281.

1860. **Agaricocr. pentagonus** Hall. Supp. Geol. Rep. Iowa, p. 57. Upper Burlington limest. Burlington, Iowa.

1861. **Agaricocr. planoconvexus** Hall (**Agaricocr.—Amphoracr.—planoconvexus**). Desc. New Spec. Pal. Crin., p. 3; also Bost. Journ. Nat. Hist., p. 280. Lower Burlington limest. Burlington, Iowa.

*1858. **Agaricocr. pyramidatus** Hall (**Actinocr. pyramidatus**). Geol. Rep. Iowa, i, pt. ii, p. 565. Lower Burlington limest. Burlington, Iowa.

Syn. **Agaricocr.** (**Amphoracr.**) **corrugatus** Hall. 1861, Desc. New Spec. Pal. Crin., p. 4; also Bost. Journ. Nat. Hist., p. 283. (Hall described here a more mature specimen).

1881. **Agaricocr. Springeri** White. Indiana Rep. for 1881 (now in press). Keokuk limestone. Crawfordsville, Ind.

1858. **Agaricocr. stellatus** Hall. Geol. Rep. Iowa, i, pt. ii, p. 564. Upper Burlington limest.—Burlington, Iowa.

1850. **Agaricocr. Whitfieldi** Troost. List. Crin. Tenn.; Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 621; Supp. Iowa, Rep. 1860, Pl. 3, fig. 5; Meek and Worthen, Geol. Rep. Ill., vol. v, p. 499, Pl. 12, fig. 1, and Pl. 15, fig. 8. Keokuk limest. Green Co., Ill.

1858. **Agaricocr. Wortheni** Hall. Geol. Rep. Iowa, i, pt. ii, p. 619, Pl. 14, fig. 1; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 240. Upper portions of Keokuk limest. Iowa, Illinois and Missouri.

Subgenus **ALLOPROSALLOCRINUS** Lyon and Cass.

1860. Lyon and Casseday. Am. Acad. Arts and Sci., vol. v, p. 29.
1866. Shumard. Cat. Pal. Foss. N. Amer., pt. i. p. 353.
1873. Meek and Worth. (in part). Geol. Rep. Ill., vol. v, p. 368.
1879. Zittel. Handbuch der Palæontologie, i, p. 370. (Not Meek and Worth., 1865, Proc. Acad. Nat. Sci. Phila., p. 164).
Syn. *Conocrinus* Troost, 1850. List of Crin. Tenn. (not defined).

Lyon and Casseday in defining the genus *Alloprosallocrinus* placed under it two species: their type *A. conicus* and *A. depressus*, the latter probably an *Agaricocrinus.* With this genus *Alloprosallocrinus* has close affinities; it differs, however, in having an almost central anal tube and not a lateral opening through the vault. The tube which extends from an elevated tuberculous dome, gives to *A. conicus* a superficial resemblance to some of the later forms of *Batocrinus*, and this induced Meek and Worthen to place Lyon's genus a mere subgenus under the other.

Meek and Worthen added a new species, but we doubt from their description of *A. euconus*, if they correctly identified Lyon's typical form, or they would have found the two species to be, superficially at least, very distinct. The form of the plates in the calyx, and particularly of those near the arm regions, is in Meek and Worthen's species like in *Batocrinus*, but in *A. conicus* almost identical with *Agaricocrinus.* We refer the former to *Batocrinus*, and place *Alloprosallocrinus* subgenerically under *Agaricocrinus.* Lyon and Casseday describe the primary radials as being composed of only 2 × 5 pieces. This is sometimes abnormally the case, but there are always as a rule three plates in each ray, of which the second are exceedingly short, linear and easily overlooked.

Amended Diagnosis.—General form turbinate; calyx truncate, slightly convex. Basals and primary radials like those of *Agaricocrinus*,, with 2 × 10 narrow secondary radials succeeding them; the interradial and anal plates also similar in their form and arrangement; but the first interradial and the second series of anal plates extend to the top of the tertiary radials, and support directly the vault pieces.

Dome elevated, conical, extended into a large, almost central anal tube; vault pieces more or less nodose, the apical plates somewhat larger, but not so distinct as in *Agaricocrinus*, and pushed more towards the anterior side. Length of anal tube unknown.

Arms large, simple so far as known; two arms from each ray, with sometimes three on one or both posterior rays.

Geological Position, etc.—The only known species occurs in the Warsaw limestone.

1860. **Alloprosallocrinus conicus** Lyon and Cass. (type). Proc. Am. Acad. Arts and Sci., vol. v, p. 29. Shumard, 1866, **Alloprosallocr.** (subg. of **Actinocr.**) **conicus**, Cat. Pal. Foss., pt. 1, p. 352. Warsaw limest. Hardin and Allen Cos., Ky.

c. MELOCRINITES.

7. MARIACRINUS Hall.

(Revised by Wachsm. and Spr.)

1859. Hall. Paleont. New York, vol. iii, p. 104.

Mariacrinus in its original form, with *M. nobilissimus*, *M. pauci-dactylus* and *M. pachidactylus* Hall as types, were shown by Schultze, Mon. Echin. Eifel. Kalk., p. 61, to be identical with *Melocrinus* Goldfuss. This is undoubtedly correct with regard to those species, but Hall described two other species, *M. plumosus* and *M. ramosus*, which in their arm-structure differ so essentially from the former, that we think it proper to separate them and reconstruct the genus *Mariacrinus* with *M. plumosus* as the type. To these two species we add *Melocrinus angustatus* Angl., and *Glyptocrinus Carleyi* Hall, which latter we find to have four basal plates instead of five, and no underbasals.

The genus *Mariacrinus*, as we propose to define it, includes only species in which the two main divisions of the ray are longitudinally separated, forming two free and equal parts, contrary to *Melocrinus*, in which the main branches are laterally connected. Hall already noticed this peculiarity in the arm-structure of *Melocrinus plumosus*, and he very correctly homologized the two inner divisions of the ray, which give off exclusively the branches, with the double-jointed brachial extensions in the ray of *M. pachidactylus*, and the outer arms of the former with the branchlets of the latter.

Zittel takes *Mariacrinus* Hall to be a synonym of *Ctenocrinus* Bronn, which we refer to *Melocrinus*, following Schultze. Hall's *M. macropetalus* will be arranged under *Corymbocrinus* Angelin, and among the Calyptocrinidæ. Its arms are yet unknown, but the arrangement of its plates agrees perfectly with that genus. *Mariacrinus stoloniferus* Hall is described only from fragmentary columns.

Amended Diagnosis.—Form of calyx obconical; general aspect and surface ornamentation similar to *Glyptocrinus;* radiating striæ passing from plate to plate; radials all along their median line elevated into high rounded ridges, somewhat resembling recumbent arms; interradial and interaxillary areæ large and depressed.

Basals four, small, almost of equal size, the one facing the anal area largest. Primary radials 3 × 5, nearly as wide as high, decreasing in size upwards; the first set joining laterally; the second enclosing the first anal and first interradial plates; the third supporting 3 × 10 secondary radials, which are generally of uniform size and vertically separated by six or more interaxillary plates. The secondary radials are followed by several tertiary radials, which vary in number with the age of the individual—mature specimens having five and even more—all placed in a direct line with the arms and somewhat resembling arm plates.

Arms four to each ray, the inner ones branching, but rarely more than once or twice, the outer arms remaining simple throughout, and taking a somewhat lateral course. The inner arms are placed close together, almost parallel with each other, their branches given off to the outer sides of the ray. Both inner and outer arms are composed of quadrangular single joints, with straight, sometimes slightly oblique sutures; the arm-bearing joints subpentagonal; main arms and branches fringed with pinnules.

Interradial areæ large, composed of a great number of plates; the first wedged in between the upper sloping sides of two first radials and two second radials; second interradial series consisting of two plates; each succeeding series of two or three.

Anal area wider; the first plate in line with the first interradials, perhaps a little larger, succeeded by three plates in the second, and a like number in all superior series.

Vault only known in *M. Carleyi*, where it is low, scarcely rising beyond the horizon of the calyx.

Interradial regions depressed and excavated between the rays, thereby giving to the form a pentalobate outline.

Radial portions prominent, toward the margin of each arm distinctly elevated and formed into a rounded ridge.

Arm openings arranged along the margin of the vault, directed upwards. The vault is composed of very minute, irregular pieces without definite arrangement, even the apical dome plates are obscure.

Anal aperture excentric, opening directly through the vault.

Form of column unknown; central canal subpentagonal and of more than medium size.

Geological Position, etc.—*Mariacrinus* is confined to the Upper Silurian, and occurs in Europe and America.

We recognize the following species:—

*1878. **Mariacrinus angustatus** Angelin. (**Melocr. angustatus.**) Iconogr. Crin. Suec., p. 20, Pl. 26, fig. 22. Upper Silur. Gothland, Sweden.

*1863. **Mariacr. Carleyi** Hall. (**Glyptocr. Carleyi.**) Trans. Albany Inst., iv, p. 203; also 28th Rep. N. Y. St. Cab. Nat. Hist., 1875, Pl. 14, figs. 7-10. Niagara gr. Waldron, Ind.

*1863. **Mariacr. obconicus** Hall. (**Melocr. obconicus.**) Trans. Albany Inst., p. 206; also 28th Rep. N. York St. Cab. Nat. Hist., 1875, Pl. 14, figs. 11-14. Niagara gr. Waldron, Ind.

1859. **Mariacr. plumosus** Hall. (Type of the genus.) Paleont. N. York, iii, p. 110 Pl. 3, figs. 6-11. Lower Helderberg gr. Herkimer Co., N. Y.

1859. **Mariacr. ramosus** Hall. Paleont. N. York, iii, p. 147, Pl. 2, figs. 2, 3. Lower Helderberg gr. Herkimer Co., N. Y.

8. TECHNOCRINUS Hall.

1859. Hall. Paleont. New York, iii, p. 139.
1879. Zittel. Handb. der. Palæontologie, i, p. 372.

According to Hall, *Technocrinus* differs from *Mariacrinus* only in the arm structure, he therefore at first arranged it subgenerically under that genus. A careful comparison of *Technocrinus*, not only with that section of Hall's *Mariacrinus* which we have referred to *Melocrinus*, but also with *Mariacrinus plumosus* the present type, has convinced us that *Technocrinus* differs in several additional points, and sufficiently, so to make it an independent genus.

Technocrinus differs from *Mariacrinus*, as now amended, in having 1 × 10 secondary radials, instead of 3–4 × 10, and these connected laterally without the interposition of interaxillaries; in having the arms given off in an almost continuous ring around the body, and not in clusters; in the straight upward direction of all the arms, contrary to *Mariacrinus* in which the outer arms are given off obliquely, and only the inner ones run parallel with each other; in that its arms are strong, simple, composed of single joints, instead of being slender, branching and double jointed. It further differs from *Melocrinus* in giving off the arms straight and directly from the body, instead of obliquely from the free rays; in the absence of interaxillaries, and in other minor characters.

Generic Diagnosis.—Form of calyx similar to *Melocrinus.* Symmetry, except in the basal portions, perfectly pentahedral.

Basals four, one of them larger and placed longitudinally in line with the primary radials of one of the lateral rays. Primary radials 3 × 5; the first two hexagonal; the third pentagonal and supporting 1 × 10 large secondary radials, which are all axillary, each supporting 2 × 2 tertiary radials, of which the upper part of the second row is laterally disconnected and free. They are succeeded by several wedge-form plates, which gradually interlock, and which are followed, rather abruptly, by two series of narrow, alternately arranged arm plates. The arms are long, simple, straight, placed around the body in a continuous ring, and at almost equal distances from each other. Pinnules apparently thin, thread-like, their sides abutting.

Interradials three to four; the first resting against the oblique upper sides of the first radials, and between the second. Anal area, so far as known, not distinct from the other interradial ones. Construction of the vault unknown. Column round.

Geological Position, etc.—*Technocrinus* has been found only in the Oriskany Sandstone of Maryland.

*1859. **Technocrinus Andrewsi** Hall. (Type of the genus.) (**Mariacr.—Technocr. —Andrewsi.**) Paleont. N. York, iii, p. 141, Pl. 86, figs. 1-4. Oriskany Sandstone. Cumberland, Md.

*1859. **Technocr. spinulosus** Hall. (**Mariacr.—Technocr.—spinulosus.**) Paleont. N. York, iii, p. 140, Pl. 85, figs. 1-18. Oriskany Sandstone. Cumberland, Md. (**Mariacr.—Technocr. sculptus** and **T. striatus** Hall, are known from the basals only).

9. **MELOCRINUS** Goldfuss.

1826. Goldfuss. Petrefacta Germaniæ, i, p. 197.
1835. Agassiz. Mem. d. l. Soc. des Sci. Natur. de Neuchatel, i, p. 196.
1841. Müller. Monatsb. Berl. Akademie, i, p. 209.
1850. D'Orbigny. Prodr. de Paléont., i, p. 103.
1852. D'Orbigny. Course Élément., ii, p. 140.
1855. Roemer. Lethæa Geogn. (Ausg. 3), p. 250.
1857. Pictet. Traité de Paleont., iv, p. 325.
1867. Schultze. Mon. Echin. Eifel Kalk., p. 61.
1875. Hall. Geol. Rep. Ohio, Paleont., ii, p. 158.
1878. Angelin. Iconogr. Crin. Suec., p. 19.
1879. Zittel. Handbuch d. Palæontologie, i, p. 371.

Syn. *Ctenocrinus* Bronn, 1840. Jahrbuch, p. 54.
Syn. *Ctenocrinus* Müller, 1855. Verhandl. Naturh. Verein, xii, p. 16.
Syn. *Castanocrinus* Roemer, 1855. Lethæa Geogn., ii, p. 252.
Syn. *Mariacrinus* Hall (in part), 1857. Paleont. N. York, iii, p. 104.
Syn. *Cytocrinus* Roemer, 1860. Silur. Fauna West. Tenn., p. 46.
Syn. *Clonocrinus* Oehlert, 1879 (not Quenstedt). Bull. Soc. Geol. de France (ser. 3), vol. vii.
Syn. *Turbinocrinites* Troost. List. Crin. Tenn., 1850 (not defined).
Syn. *Astrocrinites* Conrad. Cat. Geol. Rep. of 1840 41 (not Cumberland, 1826; nor Austin, 1843; nor *Asterocrinus* Lyon, 1857; nor Münster, 1839).

The genus *Melocrinus* holds the same relation to *Mariacrinus* as *Steganocrinus* to *Actinocrinus*, and as *Eucladocrinus* to *Platycrinus*. In all of them the construction of the body remains almost unchanged, while a remarkable modification takes place in the brachial appendages, which are extended into free rays with an indefinite number of radials, which give off the arms laterally.

This character separates the genera of the three groups very distinctly and uniformly.

Several attempts have been made to establish sub-divisions for *Melocrinus*. Roemer, in 1855, proposed the name *Castanocrinus* for species with a central or subcentral anal opening, retaining *Melocrinus* with *M. hieroglyphicus* Goldf. for species with a lateral opening. A critical comparison of all the species leads us to doubt whether that division can be carried out practically. We agree with Shultze, Mon., p. 63, that the proboscis—anal tube—is never central, and in this genus in no case actually lateral; but that its direction is more or less excentric in all species. Neither can the presence or absence of interaxillary plates, unless accompanied by other distinctive characters, be considered for a moment as sufficient for generic separation, as had been proposed in the case of *Ctenocrinus* Bronn,[1] those plates are mere accessory pieces, and may be present or absent in the same species.

Turbinocrinites Troost was proposed in MS. (according to Hall) for a species which was said to have the first anal plate in line with the first radials, but Troost's typical species *Melocr. Verneuili*, which was subsequently defined by Hall, seems not to have possessed such a plate, as Hall himself mentions expressly that the anal area is but slightly distinct from the regular interradial ones.

Cytocrinus Roemer was described by its author with probably three (?) basal plates—the exact number had not been ascertained. A good specimen in our collection from Louisville, Ky., which in every respect agrees with *C. lævis* Roemer, shows that it has four basals, and that the genus is identical with *Melocrinus*. Roemer himself gave for locality both Western Tennessee and Louisville.

Phillipsocrinus McCoy, which was described with four basals, has been frequently connected with *Melocrinus*. The generic description was made from a single specimen, and this was evidently abnormal, as indicated by having two additional plates in line with the first radials (seven in all), and we think it probable that the abnormal seventh plate in this case rendered the presence of the fourth basal plate necessary. We take it to be an abnormal specimen of *Actinocrinus*, and this is far more consistent with the given geological position.

Generic Diagnosis.—Body obconical, subglobose or pear-shaped, with five free rays extended upward and giving off arms laterally. Calyx highly ornamented with radiating ridges, sometimes with little nodules, in some species with all the plates strongly nodose or almost spiniferous; symmetry slightly bilateral.

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[1] The genus *Ctenocrinus* was at first incorrectly defined. It was described by Bronn (Jahrbuch, 1840, p. 542) with three basal plates, which was confirmed by Roemer (Leth. Geogn., 1855, p. 251), and subsequently de Koninck considered the genus identical with *Pradocrinus* de Verneuil (Crin. du terr. Carb. Belg., p. 147). Joh. Müller (Verhandl. naturh. Verein, 1855), admits more than three basals, probably five, and in 1857 (Neue Echin. Eifel Kalk, p. 255), he mentions positively five basals, and compares *Ctenocrinus* with *Glyptocrinus* Hall, asserting that it had also parabasalia. Schultze afterwards in his Monograph, p. 63, proved from more perfect specimens that *Ctenocrinus typus* has only four basals and no underbasals, which is evidently correct. One of us had an opportunity several years ago to study the Schultze collection in the Museum of Comparative Zoology of Cambridge, which contains specimens showing only four basals like *Melocrinus*.

Basals four, three of them equal and pentagonal, the fourth larger and hexagonal, the latter directed to the left antero-lateral ray, not posteriorly.

Radials 3 × 5 ; the five first hexagonal and joining laterally; the plates of the second series hexagonal, the first interradial and anal plate interposed between them; the third pentagonal and bifurcating. They support on their upper sloping sides two to three secondary radials (2–3 × 10), with one or more—though sometimes none—in the axil. The secondary radials are succeeded in a direct line by two rows of plates, which sometimes interlock, but which more frequently are placed side by side. The plates which represent higher orders of radials, are separated by a deep vertical suture, and formed into a long brachial appendage or free ray, which terminates in an arm.

The free rays give off laterally, throughout their length at certain intervals, from each third or fourth joint, or less often, and from opposite plates (not alternately), small armlets, composed of two rows of interlocking plates, with short pinnules on alternate sides. The plates which compose the appendages are wider than high, their upper and lower sides parallel, except the arm-bearing pieces which are depressed pentagonal. The length of the armlets differs according to their position ; all extend to the same general height, and hence those nearer the body are longer, the length decreasing proportionately upward.

In young specimens, all arms are given off from the free rays ; while in the adult, the lower portion of the proximal arm is often enclosed within the calyx, and sometimes even separated from the main trunk by small plates.

There is only one brachial appendage to each ray, and this, as stated before, is composed of two rows of plates which rest upon a bifurcating plate. This construction leaves no doubt that the two rows, which are separated by a deep longitudinal suture, often by interaxillary plates and small intermediate pieces scattered between them, represent two distinct brachial appendages, which became anchylosed throughout their length, contrary to *Mariacrinus*, in which under similar conditions, the equivalent parts remained detached.

Anal plates numerous. The first interradial placed upon the upper sloping sides of the first radials and between the second; the second series composed of two plates, and there are three in each succeeding series.

The posterior or anal side is but slightly distinct from the other four, but it has generally three plates in the second, and three or four in each succeeding series.

Vault very variable, highly elevated to low hemispherical; the plates comparatively large and more or less nodose, but sometimes small and scarcely convex; the interradial regions depressed. Anal aperture subcentral or almost lateral, and extended generally—if not always—into a tube, whose length is unknown.

Apical dome-plates conspicuous, particularly in species with an excentric anus.

Column round, composed alternately of longer and shorter joints; central canal small, round, or obtusely pentagonal.

Geological Position, *etc.*—*Melocrinus* ranges from the Upper Silurian to near the close of the Devonian, and is represented both in America and Europe.

We place here the following species:—

*1875. **Melocrinus Bainbridgensis** Hall (**Melocr.—Centrocr.—Bainbridgensis.**) Geol. Rep. Ohio Paleon. ii, p. 158, Pl. 13, figs. 2, 3, above Huron Shales, Devonian. Ross Co., Ohio.

*1879. **Melocr. Bigsbyi** Oehlert. (**Clonocr. Bigsbyi.**) Bull. Soc. de France (Ser. 3) vol. vii, p. 4, Pl. 2, figs. 2–4. Devonian. St. Germain, France.

(?) 1872. **Melocr. breviradiatus** Hall and Whitfield. Hamilton gr. (We have not seen the description.)

1838. **Melocr. decadactylus** Goldfuss. (**Actinocr. decadactylus.**) Nova Act. Ac. Leop. xix, p. 343, Pl. 31, fig. 5; F. Roemer, **Ctenocr. decadactylus**, Rhein. Uebergangsgeb. p. 61. Grauwacke, near Coblentz, Germ.

(**Ctenocr. decadactylus** Ad. Roemer 1850, Hartzgebirge, p. 2, Pl. 1, fig. 1. From the Devonian of the Hartz. This is probably different from the Coblentz specimens.

1833. **Melocr. gibbosus** Goldf. Petref. German. i. p. 211, Pl. 64, figs. 2; Austin, 1842, Ann. and Mag. Nat. Hist. x, p. 109; Schultze, 1867, Mon. Echin. Eifel Kalk, p. 64, Devonian. Eifel, Germ.

Syn. **Melocr. lævis** Goldf. (not F. Roemer). Petref. German., i, p. 197, Pl. 60, fig. 2.

(?) 1878. **Melocr. grannulatus** Angelin. Icon. Crin. Suec., p. 20, Pl. 26, figs. 21 and 21 a. Upper Silur. Gothland, Sweden. (This is certainly not *Melocrinus* and we doubt that it is has four basals; it differs materially in the arrangement of the anal plates.)

1826. **Melocr. hieroglyphicus** Goldf. Type of the genus. Petref. German. i, p. 197, Pl. 60, figs. 1 A–E; also Nova Act. Ac Leop., xix, p. 339; also Lethaea. Geogn., i and ii, p. 63; Roemer, 1855, Lethaea Geogn., Pl. 4, figs. 10 a, b, c. Rhein. Uebergangsgebirge. Devon. Belgium and Germany.

*1860. **Melocr. lævis** Roemer (not Goldf.)—**Cytocrinus lævis.** Silur. Fauna, West Tenn., p. 56, Pl. iv, figs. 2 a, b. Niagara gr. West. Tennessee.

*1859. **Melocr. nobilissimus** Hall. (**Mariacr. nobilissimus**) Paleont. N. York, iii, p. 105, Pl 2, figs. 1–4, and Pl. 2 A, fig. 1. Pentamerus limest. Litchfield, Herkimer Co., N. Y.

1861. **Melocr. nodosus** Hall. Geol. Surv. Wis. (Rep. of Progress), p. 19. Devonian. Iowa City.

1865. **Melocr. obpyramidalis** Winchell and Marcy. (**Actinocr. obpyramidalis**) Mem. Bost. Soc. Nat. Hist., vol. i, p. 87, Pl. 2, fig. 4. Niagara gr. Near Chicago, Ill. Miller, 1881, Cincin. Soc. Nat. Hist. (July No.).

This species was described from an imperfect cast. Hall takes it to be a synonym of **Melocr. Verneuili** Troost.

*1841. **Melocr. pachydactylus** Conrad. (**Astrocrinites pachydactylus**) Ann. Rep. Paleont. N. York, p. 34; Mather, 1843, Geol. Rep. N. York, p. 246; Hall, 1859, **Mariacr. pachydactylus,** Paleont. N. York, iii, p. 107, Pl. 3, figs. 1–4 A. Lower Helderberg gr. Schoharie, N. Y.

Syn. **Actinocr. polydactylus** (1837) Bonny (not Miller). (Schenectady Reflector.)

*1859. **Melocr. paucidactylus** Hall. Paleont. N. York, iii, p. 109, Pl. 3, fig. 5. Lower Helderberg gr. Herkimer Co., N. York.

1860. (?) **Melocr. Pratteni** McChesney. (**Forbesiocr. Pratteni**) Desc. New. Pal. Foss., p. 29; 1867, **Melocr. Pratteni** Chicago, Acad. Sci., p. 22, Pl. 5, fig. 4. (Geological position and locality unknown, and described from imperfect specimens.)

1838. **Melocr. pyramidalis** Goldfuss. Nova Acta Ac Leop., xix, i, p. 339, Pl. 31, fig. 1; D'Orbigny, 1850, Prodr., i, p. 103; Schultze, 1867, Mon. Echin. Eifel Kalk, p. 66, Pl. 4, fig. 5. Devonian. Eifel, Germ.

Syn. **Melocr. fornicatus** Goldfuss. Ibid., p. 340, Pl. 31, fig. 2.

(?) 1878. **Melocr. rigidus** Angelin. Iconogr. Crin. Succ., p. 20, Pl. 21, fig. 3. Upper Silur. Gothland, Sweden.

(This is an entirely different form, and probably belongs to a different family.)

1878. **Melocr. spectabilis** Angelin. Iconogr. Crin. Succ., p. 20, Pl. 21, figs. 1–2. Upper Silur. Gothland, Sweden.

1852. **Melocr. stellaris** Roemer. (**Ctenocr. stellaris**) Verhandl. Naturh. Verein. f. Rheinl., ix, p. 283, Pl. 2, figs. 2 a, b, c; also Schultze, 1867, Mon. Echin. Eifel Kalk, p. 65, Pl. 4, fig. 3. Devonian. Eifel, Germ.

1840. **Melocr. typus** Bronn. (**Ctenocr. typus**) Jahrb. f. Mineralogie, p. 542, Pl. 8 B; also D'Orbigny, 1850, Prodr., i, p. 103, and F. Roemer, 1844, Rhein. Uebergangsgeb., p. 60, Pl. 1, fig. 1. Grauwacke, near Coblentz, Germ. Probably identical with **Melocr. decadactylus** Goldf.

1864. (?) **Melocr. Verneuili** Troost. (**Actinocr. Verneuili**) List of Crin. Tenn., 1850; 1868, Hall, 20th Rep. N. York St. Cab. Nat. Hist., p. 327, Pl. 10, fig. 5 (Advance Sheets, 1864). Niagara gr. Decatur Co., Tenn., and Racine, Wis.

This species is only known from natural casts, hence an accurate comparison is impossible, but from all appearances it is identical with **Melocr.** (**Cytocr.**) **lævis** Roemer.

1838. **Melocr. verrucosus** Goldf. Nova Acta Ac Leop. xix, i, Pl. 31, fig. 3; also Schultze, 1867, Mon. Echin. Eifel Kalk, p. 65, Pl. 4, fig. 4. Devonian. Eifel, Germ.

1878. **Melocr. Volborthi** Angelin. Iconogr. Crin. Suec., p. 20, Pl. 7, figs. 8–11, and Pl. 23, figs. 30–32. Upper Silur. Gothland, Sweden.

(Angelin figures under this name at least two different species, his Pl. 18, fig. 16, represents even another genus; the latter possibly goes together with the specimen on Pl. 26, fig. 26, referred to **Patelliocr. fulminatus.**)

10. SCYPHOCRINUS Zenker.

1833. Zenker. Beitr. Naturgesch. d. Urwald., p. 26.
1839. Münster. Beitr. z. Petrefactenk., iii, p. 112.
1850. Quenstedt. Handbuch der Petrefactenk., p. 621.
1855. F. Roemer. Lethæa Geogn. (Ausg. 3), p. 255.
1878. Zittel. Handbuch der Palaeontologie, i, p. 372.
(Not *Scyphocrinus* Hall, 1847. Paleont. N. York, i, p. 85.)
(Not *Scyphocrinus* Pictét, 1857. Traité de Paléont., iv, p. 320.)

The genus under consideration is not to be confounded with *Scyphocrinus* Hall, 1847, which is an entirely different thing, and as we believe, a synonym of *Schizocrinus* Hall. *Scyphocrinus* Zenker, is imperfectly known, but Zittel is probably correct in grouping it with *Melocrinus*, although it has in the form of its radials, and in the large number of interradial plates, close affinities with *Periechocrinus*, from which it differs in the construction of the anal area. Pictet's identification of *Scyphocrinus* is evidently not correct; he describes it with four under basals and five basals, arranged like in *Cyathocrinus*, and otherwise resembling *Actinocrinus*.

Generic Diagnosis.—Calyx very large, composed of numerous thin plates, which are beautifully sculptured; posterior side somewhat wider, and hence the general symmetry slightly bilateral.

Basals, according to Roemer and others, five. Zittel gives their number at four. Primary radials 3 × 5, nearly of equal size and varying but little in form, all higher than wide; the two lower hexagonal; the third heptagonal and supporting two rows of secondary radials, each consisting of from four to five plates, longitudinally arranged and separated by interaxillary pieces. The radials support ten arm-trunks, which give off numerous branches, the latter closely placed together, the lower ones crossing each other and forming in the interradial and interaxillary spaces an unbroken pavement; higher up, however, the arms become free and diverge, giving off long slender branches, which in turn throw off pinnule-like armlets (Zittel), but probably true pinnules. The main trunks and branches consist of short single joints with deep ventral furrows, their articulating faces provided with radiating striæ.

Interradial series constructed of numerous plates, the first resting upon the posterior lateral sides of the first radials, and between the second radials. There are two interradials in the second series, three in the third, and others above. The posterior side differs in having three plates in the second, and four to five in the succeeding series. Construction of vault, and form and position of the anus, unknown.

Column long, round, slender, composed of short joints; central perforation round and unusually large.

Geological Position, etc.—The only known species occurs in the Upper Silurian of Bohemia.

1833. **Scyphocrinus elegans** Zenker. Beitr. Naturgesch. Urw., p. 26, Pl. 4, figs. A–F; Münster, 1839, Beitr. zur Petrefactenk., p. 112, Pl. 9, fig. 8; Quenstedt, 1850, Handb. d. Petref. p. 621, Pl. 55, figs. 1-3; F. Roemer, 1855, Lethaea Geogn. (Ausg. 3). p. 255, Pl. 4, figs. 5 a. b; Zittel, 1879, Handb. d. Palaeont. i, p. 372. Upper Silur. Karlstein, Bohemia.

11. DOLATOCRINUS Lyon.

1857. Lyon. Geol. Rep. Kentucky, iii, p. 482.
Syn. *Cacabocrinus* Troost. List of Crin. Tenn., 1850.
Syn. *Cacabocrinus* Hall. 15th. Rep. N. York, St. Cab. Nat. Hist., p. 137.

The name *Cacabocrinus* was proposed by Troost in his catalogue, but the genus was not defined until 1862 by Hall. Lyon's *Dolatocrinus*, which is identical with *Cacabocrinus*, was described in 1857 and hence has priority. Lyon described the genus with three basals, Hall with five, but we doubt if either of them ever found the sutures. The basal pieces are so closely anchylosed, that we give them simply as constituting a solidly anchylosed disk. *Dolatocrinus* differs from most allied genera in the anal area, which in its construction is not distinct from the regular interradial fields, but in this respect it resembles *Stereocrinus*, which we place subgenerically under it.

Generic Diagonis.—Body spheroidal, depressed at both poles; wider than high. Calyx forming a low spreading basin, of which the basals, the first, and partly the second radials form the bottom part; symmetry regularly pentahedral, the anal area not distinct from the other interradial series.

Vault hemispherical, depressed in the interradial portions, the radial zones elevated, giving to the summit, viewed from that side, a pentalobate aspect.

Basals united by anchylosis, without visible suture lines, and forming a pentagon; small, often barely extending beyond the circumference of the column; the median part strongly concave or the entire base funnel-shaped; central perforation or passage for the columnar canal very large, pentalobate.

Radials 3 × 5; the first large, hexagonal; the second quadrangular, generally with convex sides, narrower than either second or third, but much wider than high. The third pentagonal, and supporting at each side two secondary radials, which give off two arms to each ray. In the majority of species, however, there are two pairs of tertiary radials above the second order, or four arms to the ray. The secondary radials, and the tertiary ones if these are present, are almost as large as the second and third primaries. The arms, on becoming free, bifurcate two or three times, and it appears that they were constructed sometimes of a single series of cuneiform pieces alternately arranged, but more generally of two series of interlocking plates. Pinnules long, slender jointed.

Interradials three or more—their number greater in species with four arms than in those with two arms to the ray—generally arranged in three series. The first interradial plate very large, the largest plate in the calyx; subcircular to subovoid; resting between the upper sides of the first radials, against the sides of the second and third, and between the lower sloping sides of the first secondary radials. The second interradial series is composed of one or two plates, smaller than the first. The third series consists of two or three much smaller plates, sometimes with a fourth series above. There are generally a few interaxillary plates between the secondary radials.

Vault composed of rather large plates, ornamented with coarse granules or small irregular nodes. The apical dome plates well defined, the radial pieces slightly tuberculous, and the entire radial portions elevated; the interradial regions depressed. Anal aperture subcentral, evidently extended into a slender tube.

Column unknown, its form however was circular, and it had an unusually large, pentalobate central canal.

Geological Position, *etc.*—In the Upper Helderberg and lower beds of the Hamilton group, Devon., and only found in America.

1862. **Dolatocrinus glyptus** Hall. (**Cacabocr. glyptus**). 15th Rep. N. York St. Cab. Nat. Hist., p. 140; **Dolatocr. glyptus** S. A. Miller, Cat. Pal. Foss., p. 72. Hamilton gr. Genessee Co., N. Y.

1862. **Dolatocr. glyptus** var. **intermedius** Hall. (**Cacabocrinus**). 15th Rep. N. York St. Cab. Nat. Hist., p. 141. Hamilton gr. Livingston Co., N. Y.

1857. **Dolatocr. lacus** Lyon. (Type of the genus). Geol. Rep. Ky., iii, p. 482, Pl. 4, figs. 2 a, b, c. Encrinal limest. Beargrass quarries, Louisville, Ky.

1862. **Dolatocr. lamellosus** Hall. (**Cacabocr. lamellosus**). 15th Rep. N. York St. Cat. Nat. Hist., p. 141; **Dolatocr. lamellosus** S. A. Miller, Cat. Pal. Foss, p. 72. Western N. Y. Upper Helderberg gr.

1862. **Dolatocr. liratus** Hall. (**Cacabocr. liratus**). 15th Rep. N. York St. Cab. Nat. Hist., p. 139; **Dolatocr. liratus** S. A. Miller, Cat. Pal. Foss., p. 72. Western N. Y. Hamilton gr.

1862. **Dolatocr. liratus** var. **multilira** Hall. (**Cacabocrinus**). 15th Rep. N. York St. Cab. Nat. Hist., p. 139. Hamilton gr. Western N. Y.

1869. **Dolatocr. Marshi** Lyon. Trans. Am. Philos. Soc., vol. 13, p. 461, Pl. 27, figs. n, 1, 2. Upper Helderberg gr. Falls of the Ohio.

1862. **Dolatocr. speciosus** Hall. (**Cacabocr. speciosus**). 15th Rep. N. York St. Cab. Nat. Hist., p. 137; **Dolatocr. speciosus** S. A. Miller, Cat. Pal. Foss., p. 72. Upper Helderberg. Schoharie, N. Y.

1862. **Dolatocr. Troosti** Hall. (**Cacabocr. Troosti**). 15th Rep. N. York St. Cab. Nat. Hist., p. 138; **Dolatocr. Troosti** S. A. Miller. Cat. Pal. Foss., p. 72. Hamilton gr. Western N. Y.

Subgenus **STEREOCRINUS** Barris.

1878. Proceed. Davenport Acad. Nat. Sci., vol. ii, p. 282.

Stereocrinus in general form, mode of ornamentation, and in the construction of the plates, resembles the simpler form of *Dolatocrinus*. It differs from it in having two, instead of 3 × 5, primary radials, and the basal plates, although closely anchylosed, distinctly divided into three pieces.

Through the kindness of Rev. Dr. Barris, we examined a large number of specimens from Davenport, and became satisfied that the reduction in the number of radials is not accidental, but a constant character, which extends to more than one species. Other specimens have since been found by Dr. Barris in the Lake Superior region, which confirm this opinion. The upper radials in *Stereocrinus* are of the same size, and nearly of the same form, as the second and third radials combined in *Dolatocrinus*, and this suggests a modification from the two pieces in the one, to a single plate in the other. It is very possible that in *Dolatocrinus* the two pieces were united by syzygie,[1] while in *Stereocrinus* they became perfectly anchylosed.

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[1] In our general remarks upon the Actinocrinidæ, we have suggested that probably in genera, in which the second radial is quadrangular and transversely arranged like in *Batocrinus* and *Dolatocrinus*, this plate represents a mere hypozygial joint, which with the axillary plate forms a syzygie.

This seems to us sufficient to separate the two forms, but in other respects the relations with *Dolatocrinus* are so close, that they justify only a subgeneric division, for which we propose the following:—

Diagnosis.—Body depressed; calyx truncate up to the second radials, the latter bending abruptly and forming a low basin with straight sides. Dome but slightly elevated, its interradial portions depressed and deeply grooved toward the arm bases, giving to the radial regions a certain prominence, and to the body, viewed from the summit, a somewhat lobed appearance; symmetry strictly pentahedral.

Basal disk small, scarcely projecting beyond the column, funnel-shaped, composed of three closely anchylosed pieces. Primary radials 2 × 5; the first hexagonal; the second pentagonal, supporting two radials of the second order, the latter supporting the arms. So far as the specimens are preserved, there are only two arm openings to each ray, these, however, are so large that they may form the inner cavity of free brachial appendages with numerous arms. Arms entirely unknown.

Interradials two, large, with several small plates above; the two former in series of one each; the first the largest plate of the body, heptagonal; the second hexagonal, smaller than the radial plates; succeeding pieces placed within the depressions between the arm bases; anal side not distinct.

Vault composed of a moderate number of medium-sized pieces; apical dome-plates easily recognized by their larger size. Anal opening subcentral, extended into a tube.

Column round; central canal large, pentalobate.

Geological Position, etc.—Upper Helderberg group of America.

1878. **Stereocrinus triangulatus** Barris. Davenport Acad. Nat. Sci., p. 283, Pl. 11, figs. 1, 2. Encrinal limest. Near Davenport, Iowa.

1878. **Stereocr. triangulatus** var. **liratus** Barris. Ibid. p. 284, Pl. 11, fig. 3. Encrinal limest. Near Davenport, Iowa.

d. PERIECHOCRINITES.

12. PERIECHOCRINUS. Austin.

1842. Austin. Ann. and Mag. Nat. Hist., x, p. 109 (no definition).
1843. Austin. Ibid., xi, p. 203.
1843. Morris. Cat. Brit. Foss. (ed. 1st) p. 56.
1857. Pictét. Traité de Paléont., iv, p. 323.
1878. Angel. Iconogr. Crin. Suec., p. 6.

1879. Zittel. Handb. der Palæontologie, i, p. 368.
Syn. *Actinocrinus* Miller, 1821 (in part). Hist. Crinoidea, p. 116.
Syn. *Actinocrinus* Phillips, 1839. Murchis. Silur. Syst., p. 57.
Syn. *Trochocrinites* Portlock, 1848. Geol. of Londonderry, p. 345.
Syn. *Pradocrinus* De Verneuil, 1850. Bull. Soc. Geol. France (ser. ii), vol. vii, p. 184.
Syn. *Geocrinus* d'Orbigny, 1850. Prodr. de Paléont., i, p. 46.
Syn. *Saccocrinus* Troost, 1850. List. Crin. Tenn.
Syn. *Saccocrinus* Hall, 1852. Paleont. New York, ii, p. 205.
Syn. *Pyxidocrinus* Müller (in part), 1857. Neue Echin. Eifel Kalk, p. 253.
Syn. (?) *Trochocrinites* Pander, 1858. Helmerson's Geol. Bermerk. auf einer Reise in Schweden, etc., p. 20.
Syn. *Saccocrinus* Roemer, 1860. Silur. Fauna West. Tenn., p. 42.
Syn. *Actinocr.* (*Megistocrinus*) Hall, 1861. Bost. Journ. Nat. Hist., p. 271.
Syn. *Actinocr.* (*Pradocrinus*) Meek and Worth., 1861. Proc. Acad. Nat. Sci. Phila., p. 133.
Syn. *Actinocrinus* Hall, 1863. Trans. Albany Inst., v, p. 196.
Syn. *Megistocrinus* Winchell and Marcy, 1865 (not Ow. and Shum.). Mem. Bost. Soc. Nat. Hist., i, p. 87.
Syn. *Saccocrinus* Meek and Worth., 1869. Geol. Rep. Ill., iii, p. 347.
Syn. *Actinocr.* (*Saccocrinus*) Meek and Worth., 1869. Geol. Rep. Ill., iii, p. 470.
Syn. *Megistocr.* (*Saccocrinus*) Meek and Worth., 1873. Geol. Rep. Ill., vol. v, p. 397.
Syn. *Actinocrinus* Angelin, 1878 (in part). Iconogr. Crin. Suec., p. 6.
Syn. *Saccocrinus* S. A. Miller. Journ. Cincin. Soc. Nat. Hist. (July No.).

Austin's definition of *Periechocrinus* is not so clear as might be wished, but sufficiently distinct to imply that he described a group of Crinoids of which Miller's *Actinocrinus moniliformis* is the type. None of Austin's species were figured; the first, *P. articulosus*, is but little known, the second, *P. costatus* has been regarded a synonym of *Actinocr. moniliformis*, while the third, *P. globulosus*, has not been defined. The species are characterized by their elongate sack-like form, the thinness of their body plates, the exceedingly high radials, the conspicuous elevated ridges along the radials, the large interradial and interaxillary spaces, the wide anal area with a plate in line with the first radials, and the large, slender, more or less branching arms. This includes the American species for which Troost and Hall proposed the genus *Saccocrinus*.

It makes but little difference whether the arms in *Saccocrinus speciosus* (Hall's type) branch again after they become free, or exclusively within the body as in the case of *Periechocrinus moniliformis*, provided their mode of branching and their construction otherwise is similar, and this is evidently here the case. There are among the European species several in which the arms branch in their free state, and we find among them all possible intermediate gradations, from two simple arms in the ray to eight, and these either simple or branching. Angelin refers species with only two and four arms, if remaining simple, to *Actinocrinus*, but it seems to us, that a generic separation, based upon the number of arms, cannot be upheld in a group in which a branching of the arms is not only admitted, but very characteristic.[1]

Angelin's *Actinocr. medius* and *A. major* have underbasals, and are referred by us to the Rhodocrinidæ.

We place here with doubt Angelin's *Periechocr. Gothlandicus* and *P. radiatus*, which both differ in the secondary radials and in the style of ornamentation from all other species, while they agree on the same points and in their general aspect with *Glyptocrinus*. None of the figured specimens show the anal side, and it seems quite possible that the two species, like *Glyptocrinus*, had no anal plates in line with the first radials.

Periechocrinus grandiscutatus, *P. multicostatus*, *P. undulatus*, *P. annulatus* and *P. geometricus*, Angelin's species, were described from fragmentary plates, and their identification is doubtful, the latter even, if correctly figured, had underbasals. In that species only the plates of the two proximal rings are known, those of the second ring are angular above, instead of truncate, and hence the succeeding ring must have been alternately arranged.

According to our interpretation, *Periechocrinus* includes also several species from the lower Subcarboniferous, which heretofore have been variously referred to *Actinocrinus*, *Megistocrinus*, or *Pradocrinus*, but only species with thin plates and elongate body, leaving those with heavy plates, depressed body, and short radials under *Megistocrinus*.

We are aware that we include in this genus some species which possess a simple anal opening, others with apparently a small ventral tube, but we were obliged to do so, because the construction of the ventral disk is so little known, that a subgeneric division in this case could not as yet be carried out practically.

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[1] In *Actinocrinus* the case is similar, some species having four, others eight simple arms, and the last survivors of the genus have their arms branching in the free state as in species of *Periechocrinus*.

Pradocrinus de Verneuil, 1850, is identical with Austin's genus, also *Geocrinus* d'Orbigny, which was proposed the same year, and based upon Miller's *Actinocr. moniliformis.* Joh. Müller referred *Pradocrinus* to his *Pyxidocrinus*, a genus in which he proposed to embrace those species of the *Actinocrinus* group which possess interaxillary plates. Angelin identifies *Trochocrinus* Pander with *Periechocrinus*, while Bigsby takes it to be a synonym of *Glyptocrinus. Trochocrinites Gothlandicus*, certainly differs in several respects from typical species of *Periechocrinus.*

The name *Trochocrinites* was preoccupied by Portlock in 1848. His only species *P. lævis* was described from a very imperfect specimen, and we cannot accurately determine its relations, though it seems to be allied to the group of *P. Gothlandicus.* It is certainly quite distinct from Angelin's *P. lævis.* We should be inclined to place this species with *P. Gothlandicus*, *P. radiatus*, and *P. pulcher* in a separate group under Portlock's name, but it is possible they all belong to *Glyptocrinus*, and we dislike to encumber the subject with generic separations based upon such imperfect data.

Austin made *Periechocrinus* the type of a distinct family, and included in it *Sagenocrinus*, while Pictêt and Zittel refer it to the Actinocrinidæ.

Generic Diagnosis.—Body large, elongate and somewhat urn-shaped; composed of thin, almost smooth or delicately sculptured plates; radials marked along their centres with a conspicuous elevated ridge, passing from plate to plate, which divides upon each axillary piece, and which toward the arm-bases increases in prominence, until it gradually becomes identified with the free arms. Symmetry bilateral.

Basals three, of equal size, united into a spreading cup; articulating facets for the reception of the column wide.

Primary radials 3 × 5, comparatively long and narrow, connecting line unusually short, sometimes joining only by the point of an angle. The first radials large, alternately hexagonal or heptagonal; the second hexagonal and smaller; the third smaller than the second, hexagonal or heptagonal, with an obtuse upper angle supporting the secondary radials. The latter usually consist of 2 × 10 plates, the upper row, in some species, curving outward and supporting the free arms, in others straight, axillary, and supporting the higher orders of radials, which give off the arms from every second plate, and alternately from opposite sides. The arms in either case are simple or branching, long, slender, rounded, decreasing in width upward. They are from the body up composed of two series of small alternating pieces, and the bifurcating takes place after the arms have passed into a double series of interlocking pieces.

Pinnules slender, closely abutting.

Interradial plates numerous; the first one large, generally hexagonal, supporting two plates in the second, and two in the third range, with several series above, each containing from two to three plates, which gradually decrease in size toward the summit. The posterior side much wider; first anal plate heptagonal, equal in form to the first radials and in line with them, followed by three plates in the second series, and by a large number of small plates above.

Interaxillaries numerous. Vault depressed, from moderately convex to almost flat; composed of small, irregularly arranged, smooth pieces, among which the apical plates are indistinctly represented. Anus subcentral, either in form of an opening through the vault, or in some species probably extended into a small tube.

Column large, round, central canal moderately wide and round.

Geological Position, etc.—*Periechocrinus* occurs from the Upper Silurian to the base of the Subcarboniferous (Burlington Limest.), and is found both in America and Europe.

We recognize the following species :—

*1861. **Periechocrinus amplus** Meek and Worth. (**Actinocr. Pradocr. amplus**). Proc. Acad. Nat. Sci. Phila., p. 133; also 1868, Geol. Rep. Ill., iii, p. 470, Pl. 16, fig. 2. Upper Burlington limest. Burlington, Iowa.

1843. **Periechocr. articulosus** Austin. Ann. and Mag. Nat. Hist., xi, p. 204. Upper Silur. Dudley, Eng.

*1850. **Periechocr. Baylii** de Verneuil. (**Pradocr. Baylii**) Bull. Soc. Géol. de France (ser. ii), vol. vii, p. 184, Pl. 4, figs. 11 a, b, c. Devonian. District Sabero, Spain.

*1878. **Periechocr. brevimanus** Angel. (**Actinocr. brevimanus**) Iconogr. Crin. Suec., p. 6, Pl. 18, fig. 12. Upper Silur. Gothland, Sweden.

*1863. **Periechocr. Christyi** Hall. (**Actinocr. Christyi**—not Shum., 1855) Trans. Albany Inst., iv, p. 196; (Abstr., p. 2); Meek and Worth, 1868, **Saccocr. Chrystyi,** Geol. Rep. Ill., iii, p. 347, Pl. 5, fig. 1; also Hall, 1879, 28th Rep. N. Y. St. Cab. Nat. Hist. (ed. ii), p. 127, Pl. 13, figs. 12–20. Niagara gr. Waldron, Ind., near Chicago, Ill.; and Racine, Wis.

Syn. **Actinocr. Whitfieldi** Hall, 1868. 20th Rep. N. York St. Cab. Nat. Hist., p. 326; **Actinocr. (Saccocr.) Whitfieldi** Hall. Ibid. (Revised Ed.), 1870, pp. 370 and 430.

Syn. **Megistocr. Marcouanus** (1860) Winchell and Marcy. Mem. Bost. Soc. Nat. Hist., i, p. 87, Pl. 2, fig. 5. S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (July number), considers it a good species.

Syn. **Megistocr. infelix** Winch. and Marcy, 1866. Ibid., p. 7.

*1858. **Periechocr. Gothlandicus** Pander. (**Trochocrinites Gothlandicus**) Helmerson's Geol. Bemerk. auf einer Reise in Schweden und Norwegen, p. 20, Pl. 3, figs. a, b, d, e (not c); Angelin, 1878, **Periechocr. gothlandicus,** Iconogr. Crin. Suec., p. 7, Pl. x, figs. 3, 4. Upper Silur. Gothland, Sweden.

This species and **P. radiatus** differ from the typical form of the genus.

1878. **Periechocr. interradiatus** Angl. Iconogr. Crin. Suec. Figured without description, Pl. 19, fig. 15. Upper Silur. Dudley, Eng.

*1848. **Periechocr. lævis** Portlock. (**Trochocrinites lævis**) Geol. of Londonderry, p. 345, Pl. 15, fig. 1. Silurian. Tyrone, Ireland.

*1880. **Periechocr. Lindströmi** Wachsm. and Spr. (Described by Angelin as **Actinocr. interradiatus** = **Periechocr. interradiatus**—not the previous species from Dudley). Iconogr. Crin. Suec., p. 6, Pl. 26, fig. 15. Upper Silur. Gothland, Sweden.

This species was named in honor of Prof. Lindström of Stockholm.

*1878. **Periechocr. longidigitatus** Angel. (**Actinocr. longidigitatus**) Iconogr. Crin. Suec., p. 6, Pl. 26, figs. 19, 19 a. Upper Silur. Gothland, Sweden.

*1878. **Periechocr. longimanus** Angel. (**Actinocr. longimanus**). Iconogr. Crin. Suec., p. 6, Pl. 15, fig. 17 and Pl. 26, fig. 16; Pl. 28, figs. 5 and 6. Upper Silur. Gothland, Sweden.

*1878. **Periechocr. minor** Wachsm. and Spr. (Desc. by Angel. as **P. lævis,** not **P. lævis** Portlock's sp.) Iconogr. Crin. Suec., p. 7, Pl. 18, fig. 11. Upper Silur. Gothland, Sweden.

1821. **Periechocr. moniliformis** Miller. (**Actinocr. moniliformis**). Type of the genus, Nat. Hist. Crinoidea, p. 116; Phillips, 1839, Murchison's Silur. Syst., p. 673, Pl. 18, fig. 4; d'Orbigny, 1850, **Geocr. moniliformis** Prodr., i, p. 46; Angel., 1878, Iconogr. Crin. Suec., Pl. 19, figs. 14, a, b, c. Upper Silur. Dudley, Eng.

Syn. **Periechocr. costatus** Austin, 1843. Ann. and Mag. Nat. Hist., xi, p. 204.

*1878. **Periechocr. nubilus** Angelin. (**Actinocr. nubilus**). Iconogr. Crin. Suec., p. 6, Pl. 18, fig. 14. Upper Silur. Gothland, Sweden.

*1875. **Periechocr. ornatus** Hall. (**Saccocr. ornatus**). Geol. Rep. Ohio Paleont., ii, p. 126, Pl. 6, figs. 7, 9. Niagara gr. Yellow Springs, O.

*1854. (?) **Periechocr. pulcher** (Salter MS.) McCoy. (**Actinocr. pulcher**). Synop. Brit. Pal. Foss., p. 55, Pl. 1 d, fig. 3. Upper Silur. Wales.

(This species is not well known, and may possibly belong to a separate group with **P. radiatus, P. gothlandicus,** or may be a **Glyptocrinus.**)

*1878. **Periechocr. quinquangularis** Angel. (**Actinocr. quinquangularis**). Iconogr. Crin. Suec., p. 6, Pl. 16, figs. 27, 27 a, 28. Upper Silur. Gothland, Sweden.

1878. (?) **Periechocr. radiatus** Angel. Iconogr. Crin. Suec., p. 7, Pl. 10, figs. 1 and 2, and Pl. 23, fig. 3; and Pl. 27, figs. 6, 7. Upper Silur. Gothland, Sweden.

This form differs in the size, in the style of ornamentation, and the greater number of secondary radials, from the typical species.

1878. **Periechocr. scanicus** Angel. Iconogr. Crin. Suec., p. 7, Pl. 19, figs. 16, 16 a. Upper Silur. Gothland, Sweden.

*1878. **Periechocr. Schultzianus** Angel. (**Actinocr. Schultzianus**). Iconogr. Crin. Suec., p. 6, Pl. 18, fig. 13. Upper Silur. Gothland, Sweden.

*1867. (?) **Periechocr. semiradiatus** Hall. (**Saccocr. semiradiatus**). 20th Rep. N. Y. St. Cat. Nat. Hist., p. 37, Pl. 10, fig. 1. Niagara gr. Racine, Wis. Desc. from natural casts.

*1862. **Periechocr. speciosus** Hall. (**Saccocr. speciosus**). Paleont. N. Y., ii, p. 205, Pl. 44, figs. 1 and 2; also Roemer, 1860, Silur. Fauna West. Tenn., p. 42, Pl. 3, fig. 4. Niagara gr. Western Tennessee.

*1861. **Periechocr. tenuidiscus** Hall. (**Actinocr.** (?) **tenuidiscus**). Desc. New Spec. Pal. Crin., p. 14. Lower Burlington limest. Burlington, Iowa.

*1861. **Periechocr. Whitei** Hall. (**Actinocr.—Megistocr.—Whitei**). Desc. New Spec. Pal. Crin., p. 2; also Bost. Journ. Nat. Hist., p. 271; Meek and Worthen, 1873, **Megistocr. Saccocr.** Whitei, Geol. Rep. Ill., v, Pl. 6, fig. 1. Lower Burlington limest. Burlington, Iowa.

The name of this species was printed originally **Actinocr. Megistocr. olliculus**, but Hall changed it before publication in writing as given above. Among the Photogr. Plates subsequently published by Hall of some of his new species (drawn by Whitfield and photographed by Haines), we find that through mistake fig. 6 on Pl. 4 has been referred to **Megistocr. Whitei.** This is beyond doubt Hall's **Actinocr. glans,** an entirely different form, which has a long slender anal tube and *simple* arms, the reverse of **Megistocr. Whitei,** which has an anal opening *through the test* and branching arms. The original, formerly in the collection of Rev. Wm. H. Barris, and now in the Museum of Comp. Zoology at Cambridge, was returned by Hall labeled **Actinocr. eryx,** which is identical with **Actinocr. glans.** The type specimen of **Megistocr. Whitei** is in the Museum at Ann Arbor.

13. ABACOCRINUS Angelin.

1878. Angelin. Iconogr. Crin. Suec., p. 19.
1879. Zittel. Handbuch der Palæontologie, i, p. 373.

Syn. *Actinocrinus* Goldfuss (in part', 1826. Petref. Germ., i, p. 194.

Abacocrinus has its closest affinities with *Megistocrinus* Owen and Shum., from which it differs in the number of basals, and perhaps (?) in the construction of the vault, which in the former is not known. It differs from *Periechocrinus* in being composed of heavier plates, and in the number of basals.

Angelin places *Abacocrinus* with *Corymbocrinus* into a separate family. The two agree remarkably in the arm structure, and both have four basals; but the latter plates which in *Abacocrinus* are large and formed into a cup, in *Corymbocrinus* are very small, hidden from view, and located within a deep funnel as in the case of *Eucalyptocrinus*. With this genus and the allied *Callicrinus*, *Corymbocrinus* agrees in the general construction of the calyx so closely, that it would be difficult to distinguish them even generically, unless the vault and arms were preserved. We therefore arrange *Corymbocrinus* with the Calyptocrinidæ,

Zittel places *Abacocrinus* and *Cromycrinus* both under the Melocrinidæ.

Generic Diagnosis.—Body large, oblong. Calyx ovoid to subglobose ; composed of numerous, rather heavy and convex plates ; symmetry bilateral.

Basal disk convex, largely extending beyond the column ; composed of four unequal plates, with a shallow concavity for the reception of the column. Primary radials 3 × 5, the two proximal ones much wider than high ; the first pentagonal or hexagonal, and owing to the irregular number of basals, differing somewhat in form. The second radials are hexagonal, except the posterior ones which are pentagonal, smaller than the first. The third irregularly pentagonal or hexagonal, depending on the relative size of adjoining interradials, sometimes even heptagonal.

Secondary radials 2 × 10 ; comparatively large, supporting two rows of from five to six plates each, transversely arranged, alternating with each other, and laterally interlocking. The first series comparatively higher, the succeeding plates gradually decreasing in length but increasing in width. The two rows resemble, and evidently were, interlocking arm plates, which in geological times and by age became fixed and enclosed within the body ; they form the two main trunks of the ray, which divides on becoming free, each branch dividing several times again, but irregularly at uneven intervals.

Arms branching, long, gradually tapering, from the base up composed of two rows of plates, which increase to four when the bifurcation takes place. Pinnules long.

Interradials numerous, with one plate in the first, two in the second, and generally a single one in the third series, all large and nearly of equal size. The fourth series has generally but one plate, which is followed by several other series of smaller plates, each composed of from two to three pieces. The first anal plate is octangular, exceedingly large, larger even than the first radials.

It lies directly above one of the basals, resting upon its truncate upper side. Second series composed of three plates, the middle one extending beyond the other two; the two outer ones in line with the second series of interradials (not the first as is usually the case), and rests against the superior edges of the second (not the first radials), these again are followed by five or six rows of plates, generally of three each, which decrease in size upward. The plates of the interaxillary areæ are numerous.

There is a single large plate in each of the two first series, which, together with the upper interradial plates, connect the two main arm-trunks with the body walls. Construction of the vault unknown.

Column large, composed of rather high, alternately thicker and thinner joints.

Geological Position, etc.—Abacocrinus, so far as known, is confined to the Upper Silurian of Europe.

Angelin places here the following species:

1878. **Abacocrinus Cappelleri** Angelin. Iconogr. Crin. Suec., p. 19, Pl. 3, figs. 8, 8 a. Upper Silur. Gothland, Sweden.

1878. **Abacocr. medius** Angelin. Iconogr. Crin. Suec., p. 19, Pl. 24, fig. 1. Upper Silur. Gothland, Sweden.

1878. **Abacocr. tessellatus** Angl. Iconogr. Crin. Suec., p. 19, Pl. 18, fig. 6, and Pl. 23, figs. 24, 25. Upper Silur. Gothland, Sweden.

1826. **Abacocr. tesseracontadactylus** Goldf. (**Actinocrinus tesseracontadactylus**), Petref. German, i, p. 194, Pl. 59, fig. 5; Angelin, 1878, **Ababocrinus**, (type of the genus). Iconogr. Crin. Suec., p, 19, Pl. 18, figs. 2, 5, and Pl. 23, figs. 23, 23 a. Upper Silur. Gothland, Sweden.

14. MEGISTOCRINUS Owen and Shumard,

1852. Ow. & Shum. U. S. Geol. Rep. Iowa. Wis. & Minn., p. 594.
1857. Lyon. Proc. Acad. Nat. Sci. Phila., p. 412.
1858. Hall. Geol. Rep. Iowa. i., pt. ii, p. 479.
1859. Lyon & Casseday. Amer. Jour of Sci., vol. 28, p. 243.
1862. White. Proc. Bost. Soc. Nat. Hist., p. 16.
1869. Meek & Worth. (in part). Proc. Acad. Nat. Sci. Phila., p. 163.
1873. Meek & Worth. (in part). Geol. Rep. Ill, v, p. 393.
1876. White. Proc. Acad. Nat. Sci., Phila., p. 29.
1878. Barris. Proc. Davenport. Acad. Nat. Sci., ii., p. 285.
1879. Zittel. Handbuch der Palæontologie, i, p. 371 (not Hall, 1861, Bost. Journ. Nat. Hist., p. 271; nor Winchell and Marcy, 1866, Mem. Bos. Soc. Nat. Hist., pp. 87 and 110 = *Periechocrinus*),

Syn. *Actinocrinus* Hall, 1858. Geol. Rep. Iowa, i, pt. ii, pp. 571 and 573.

Syn. *Actinocrinus* Lyon, 1857. Geol. Rep. Ky., iii, p. 479.

Syn. *Sagenocrinus* Angelin, 1878 (in part). Iconogr. Crin. p. 8.

This genus is closely allied to *Abacocrinus*, but differs essentially in the number of basals, and in the disposition of the anal plates. It differs from *Periechocrinus* in the depressed form of the body, in the robust nature of its plates, and in the construction of the vault.

By former authors, and originally by Owen and Shumard, *Megistocrinus* was referred subgenerically to *Actinocrinus*. It was thereby sufficiently distinguished as long as the majority of all Actinocrinidæ were referred to the genus *Actinocrinus*, but since this has been subdivided and restricted to a limited group, it is evident that *Megistocrinus* should form a distinct genus. Angelin made it a synomym of *Sagenocrinus* but this has underbasals and single-jointed branching arms.

Generic Diagnosis.—Species generally large. Body depressed, wider than high; calyx in form of a cup or basin, of which the lower portions, up to the middle of the first radials, form the bottom part; plates heavy; dome not much elevated; symmetry bilateral.

Basals three, of equal size, spreading horizontally and producing an equilateral, hexagonal disk, which is either on the same plane with the surrounding radials and first anal plate, or, which forms between those plates a sunken area without any further concavity. Primary radials 3 × 5, almost of like form, slightly decreasing in size upward; all wider than high, and generally hexagonal. The third radials have an obtuse angle, and support from their sloping sides a single secondary radial, which is either axillary and succeeded by 1 × 2 × 10 tertiary radials, or is followed by two rows of plates which are arranged transversely, alternating with each other and interlocking, and which, as in *Abacocrinus*, form the main trunks of the arms. In species with tertiary radials these support two rows of plates, similar to those of the preceding order, and there are within the body three or four arm trunks instead of two.

Arms bifurcating throughout their length, and in a similar manner as in the preceding genus. The arms, from the body up, are composed of two rows of short joints, and are fringed with long, round pinnules.

Interradials numerous; one in the first, two in the second, and three in the third series, with several more ranges of minute pieces above. First anal plate in line with the first radials, and of the same form and proportions; succeeded by three plates in the second, three or four in the third, and a number of irregular small plates above. Axillary pieces three or more, which, with the upper interradial pieces, connect the lower portions of the arms with the body.

Vault depressed, slightly convex, composed of a great number of pieces, irregularly arranged, which surround the considerably larger, and generally nodose or spiniferous apical plates. The central plate is always very conspicuous, and is enclosed either directly by the proximal dome plates (but only in very small pieces and in young specimens), or it is, more frequently, separated from the others by a broad ring of small pieces, which also separate the proximal plates from each other. The first radial dome plates are large, isolated and pushed near the margin of the ventral disk. Anal opening on top of a short proboscidiform protuberance, which in Devonian species is placed more or less excentric, while in all species from the Subcarboniferous it is strictly lateral and located within the horizon of the arm-bases.

Column round, very strong, composed of alternately thicker and thinner joints, with large lateral cirrhi toward the lower end, and an enormous root; articulating faces of all columnar joints strongly marked with radiating lines; central canal very large and decidedly pentalobate.

Geological Position, etc.—*Megistocrinus* ranges from almost the base of the Devonian to the Burlington limestone, where it becomes extinct. It is only known from America.

We recognize the following species:—

1857. **Megistocrinus abnormis** Lyon. (**Actinocr. abnormis**). Geol. Rep. Ky., iii, p. 479, Pl. 4, figs. 1 a, b. Encrinal limest. Devonian. Louisville, Ky.

*1858. **Megistocr. brevicornis** Hall. (**Actinocr. brevicornis**). Geol. Rep. Iowa, i, pt. ii, p. 571, Pl. 10, figs. 4 a, b. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. superlatus** Hall, 1858. Geol. Rep. Iowa, ii, p. 572.

Syn. **Actinocr. minor** Hall, 1858. Ibid., p. 573.

1862. **Megistocr. crassus** White. Proc. Bost. Soc. Nat. Hist., ix, p. 17. Lower Burlington limest. Burlington, Iowa.

1862. **Megistocr. depressus** Hall. 15th Rep. N. York St. Cab. Nat. Hist., p. 134. Hamilton gr. Western N. York.

1850. **Megistocr. Evansii** Owen and Shum. (Type of the genus). **Actinocr. Evansii.** Jour. Acad. Nat. Sci. Phila. (new ser.), vol. i, pt. ii, p. 68; **Megistocr. Evansii**, 1852, U. S. Geol. Rep. Iowa, Wisc. and Minn., p. 594, Pl. 5 A, figs. 3 a, b. Lower and Upper Burlington limest. Burlington, Iowa.

Syn. **Megistocr. plenus** White. Proc. Bost. Soc. Nat. Hist., ix, p. 16.

Syn. **Megistocr. parvirostris** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 165; Geol. Rep. Ill., vol. v, p. 396, Pl. 6, fig. 7.

Megistocr. Evansii was described from the Lower, and **M. plenus**, and **M. parvirostris** from the Upper Burlington limestone. The latter is evidently only a young specimen of **M. plenus**, which cannot be distinguished sufficiently from the lower bed form. It is highly probable that **M. brevicornis** is likewise a young stage of **M. Evansii.**

1876. **Megistocr. Farnsworthi** White. Proc. Acad. Nat. Sci. Phila., p. 29. Hamilton gr., Devon. Solen and Iowa City, Iowa.

1857. **Megistocr. Knappi** Lyon. Proc. Acad. Nat. Sci. Phila., p. 412, Pl. 4, figs. 6 a, b. Upper Helderberg, Louisville, Ky.

1858. **Megistocr. latus** Hall. Geol. Rep. Iowa, vol. i, pt. ii, p. 480, Pl. 1, figs. 1 a, b. Hamilton gr. New Buffalo, Iowa.

1878. **Megistocr. nodosus** Barris. Proc. Davenport Acad. Nat. Sci., vol. ii, p. 285, Pl. 2, fig. 4. Encrinal limest. Near Davenport, Iowa.

1862. **Megistocr. Ontario** Hall. 15th Rep. N. York St. Cab. Nat. Hist., p. 136. Hamilton gr. Western New York.

1859. **Megistocr. rugosus** Lyon and Cass. Amer. Journ. Sci., vol. 28, p. 243. Encrinal limest. Louisville, Ky.

1861. **Megistocr. spinosulus** Lyon. Proc. Acad. Nat. Sci. Phila., p. 413, Pl. 4, figs. 7 a, b. Upper Helderberg gr. Louisville, Ky.

Either this species is incorrectly figured, or it does not belong here. It slightly resembles **Hadrocrinus** Lyon.

e. ACTINOCRINITES.

15. ACTINOCRINUS Miller.[1]

1821. Miller. History of the Crinoidea, p. 90.
1844. McCoy. Synop. Carb. Foss. Ireland.
1853. De Koninck and Lehon. Rec. Crin. Belg., p. 125.
1855. Roemer. Lethæa Geogn. (Ausg. 3), p. 246.
1866. Meek and Worthen. Geol. Rep. Ill., ii, p. 149.
1869. Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 153.
1873. Meek and Worthen. Geol. Rep. Ill., v, p. 340.
1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 241.
1878. Zittel. Handb. der Palæontologie, i, p. 369.
Not Angelin, 1878. Iconogr. Crin. Suec., p. 6.

Under *Actinocrinus* a very large number of forms have been described from America and Europe, and from the Upper Silurian to near the close of the Subcarboniferous, which were afterwards referred to independent genera. There can be, however, no doubt as to the group which should keep the name, as fortunately all of

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[1] In the list of references we quote only those publications which have a direct or indirect bearing upon the present, greatly restricted form of the genus. The following writers embraced with it, more or less, the entire family: Agassiz, 1835; Goldfuss, 1826-1831; Phillips, 1836-1839; McCoy, 1844; Austin, 1842; D'Orbigny, 1850; Owen and Schumard, 1850-1852; de Kon. and Lehon, 1853; Shumard, 1855 and 1866; Pictet, 1857; Joh. Müller, 1857; Hall, 1858, 1860 and 1861; McChesney, 1860; Schultze, 1867.

Miller's typical species, with a single exception, belong to the same division, and his *A. triacontadactylus* and *A. polydactylus* must form the types.[1] The genus *Actinocrinus*, as amended by Meek and Worthen, and as it is now understood, embraces almost the majority of all European Actinocrinidæ, while it includes in this country, although represented by even more species, only a comparatively small portion of the general representation of the family.

Meek and Worthen, after carefully restricting the genus, separate it in vols. ii and v of the Illinois Report into two sections:

A. The arms given off directly from the body and forming a continuous ring around it; the divisions of the ray taking place in the calyx proper, which has a more or less subconical form.

B. The radials, from the third primary up, bend abruptly outward, forming protruding lobes, which at the interradial spaces produce deep sinuses. The divisions take place in the lobes, which frequently are extended into free rays, and these giving off the arms.

Looking at the species of the two sections, and particularly at *A. proboscidialis* with only twenty arms on the one hand, and *A. Lowei* with fifty or sixty arms on the other; these distinctions seem to acquire almost generic value; but comparing species with a more nearly equal number of arms, it will be found that the division cannot be carried out practically, at least not among the European species, which in the majority of cases form a link between the two extremes of the American species.

The genus *Actinocrinus* has frequently been confounded with *Batocrinus*, and neither Casseday, the founder of the latter, nor Meek and Worthen, who recognize it, have pointed out any distinctions which warrant their generic division. Such, however, do exist, as we hope to prove.

In *Actinocrinus* and other Actinocrinites, the anal area, as a rule, has but a single special anal plate, and this located between the two first primary radials. There are two plates in the second series which are in line with—and take the place of—the larger first interradial in other series, contrary to *Batocrinus* and all other groups of the Actinocrinidæ, which in that series have three plates, or, as we express it, also a special anal plate in the second series. In *Batocrinus* the second primary radials are linear and quadrangular, in *Actinocrinus* hexagonal and of a similar form as the first radials. The secondary radials in the former contain two or even three pieces, while in the latter the same order of radials, and all others above the first, have but a single series of plates.

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[1] Roemer in 1855 restricted the genus *Actinocrinus* to the Subcarboniferous, and included in it only such species which at the arm regions are provided "mit rundlichen Falten," and in which the vault is elevated and extended into a proboscis. He refers all Silurian and Devonian species previously described under *Actinocrinus*, to distinct families.

In *Batocrinus* the arms, from the first joint up, are composed of a double series of small pieces, while these plates in *Actinocrinus* are preceded by two, three or more large cuneate single joints. In both genera the species show a great variability in the number of their arms, but while in *Actinocrinus* the whole number of arms is equally divided among the rays, in *Batocrinus* the rays adjoining the posterior side frequently have the greater number. In the former, all divisions of the ray are given off alternately from opposite sides, the branches remaining simple; in *Batocrinus*, the divisions are equal, and each branch bifurcates again; there are, however, rarely more than two divisions from each ray, except toward the posterior side, where the inner division of the rays have sometimes two additional bifurcations.

Closer than with *Batocrinus* are the relations with *Gennæocrinus*, which, as has been stated, occupies an intermediate position between *Actinocrinus* and *Batocrinus*, and which, preceding them in geological times, represents a link between the two genera.

We place McCoy's *Phillipsocrinus* provisionally under *Actinocrinus*, which it resembles very closely in its general habitus. It has the same peculiar ornamentation, is lobed, has a strong subcentral anal tube, nodose vault-pieces, but it has, according to description, four basals and only 2 × 5 radials. The latter was evidently a mistake, most probably the third radials were strongly bent outward and not preserved. McCoy had only a single specimen for description, and that this was an abnormal one is sufficiently proved by the presence of seven plates in the second range. It is very possible that the malformation made the additional plate in the basal ring necessary, for there is no other specimen with four basals known from the Subcarboniferous. Pictét refers *Phillipsocrinus* to *Melocrinus*, which we cannot indorse.

Generic Diagnosis.—Body turbinate, more or less lobed at the arm-regions; calyx beautifully ornamented with radiating striæ, which concentrate at the middle of the plate, where they form into a more or less prominent node; vault extended into a large subcentral anal tube.

Basals three, equal, rather large, and forming a shallow cup, the lower side slightly excavated for the column. Primary radials 3 × 5, the first larger than the rest, alternately hexagonal and heptagonal, generally higher than wide; the second hexagonal, smaller than the first, its height almost as great as its width; the third pentagonal and smaller, frequently bent outward, sometimes abruptly, and forming the base of a lateral extension, which gives to the radial portions a lobed, and to the general body a stellate form. Secondary radials 1 × 10, axillary. Succeeding orders of radials composed of a single series of plates to each division of the ray, the one axillary, the other simple. The simple plate is succeeded by a number of brachials connected with the body, which jointly form a fixed branch in a lateral direction.

The axillary plate supports always toward the opposite side of the preceding order the next series of radials, and so on alternately until the full number of arms of the species is produced. Arms numerous, not bifurcating in their free state, or rarely so; their number very variable, ranging among the different species from not less than twenty to fifty or more; and these equally divided among the rays. The arms are long, rather heavy, their upper ends round or somewhat flattened, the tips infolded. They are composed of a double series of narrow plates, separated by a zigzag suture. The pinnules are long, given off, like in the case of all double-jointed arms, from every joint and from both rows, they are laterally compressed, with the abutting sides flat. The joints of which the pinnules are composed are long, and they are provided at their outer side, near the middle, with a tooth-like spine, sometimes of considerable length, which is curved upward in form of a hook. The inner side of the joints is deeply grooved, and covered with two rows of small alternate plates. The pinnules are laterally attached, and resemble a fine network; those of the same arm rest tightly against those of the opposite row, thus closing the ventral furrows both of arm and pinnules, in case the arms are folded.

The interradials generally consist of three large plates, almost of equal size. There is one in the first, and two in the succeeding series, the third series consisting either of one large or of two comparatively small pieces, a fourth series is but rarely observed. The posterior side has a special anal plate in line with the first primary radials, and is of equal size with them. There are two plates in the second, smaller than the first interradial at the other sides, and one, two or three plates in the succeeding series. Interaxillary plates may be present or absent, their number never exceeds three.

The vault is composed of rather conspicuous plates, all proximal and radial dome plates nodose or tuberculous, the others merely convex, with the exception of the centre plate, which is prominent, larger than the rest, and which toward the anterior side forms the base of the anal tube. The tube is almost central, strong, composed of heavy pieces, and sometimes extends beyond the limits of the arms.

Inner floor of the vault, along the interpalmar spaces, strengthened by braces, which increase in thickness outward, leaving open galleries which diverge to the arm bases. There is a respiratory (?) pore apparently at the side of each arm opening; they however, are but rarely observed, owing to imperfect preservation of the arm bases.

Column long, moderately heavy, its joints frequently sharply edged; central canal round or pentalobate, and of medium size.

Geological Position, etc.—The genus is strictly Subcarboniferous, and has been found only in the lower and middle portions of that formation. In America it does not extend vertically beyond the Keokuk limestone; geographical distribution wide.

We recognize the following species :—

1853. **Actinocrinus armatus** De Koninck and Lehon. Rech. Crin. Belg., p. 138, Pl. 4, figs. 4, a, b, c; Meek and Worthen, Geol. Rep. Ill., ii, p. 149. Mount. limest. Tournay, Belgium.

1869. **Actinocr. asperrimus** Meek and Worthen. (**Strotocr.** (?) **asperrimus**). Proc. Acad. Nat. Sci. Phila., p. 160; also Geol. Rep. Ill., v, p. 349, Pl. 8, fig. 3. Lower Burlington limestone (not Upper, as stated by Meek and Worthen).

This is a regular transition form between **Actinocrinus** and **Teleiocrinus**, but as the rim is interrupted not only at the interradial, but also over the interaxillary spaces, we arrange it with **Actinocrinus**.

1860. **Actinocr. brontes** Hall (Sect. A). Supp. Geol. Rep. Iowa, p. 47; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Keokuk limest. Keokuk, Iowa.

1861. **Actinocr. clarus** Hall (Sect. B). Desc. New Sp. Crin., p. 2; also Bost. Journ. Nat. Hist., p. 277, Photgr. Pl. 2, figs. 24, 25; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1858. **Actinocr. cœlatus** Hall (Sect. B). Geol. Rep Iowa, i, pt. ii, p. 585, Pl. 10, figs. 14, a, b; Meek and Worthen, Geol. Rep. Illinois, v, p. 341. Lower Burlington limest. Burlington, Iowa.

1844. **Actinocr. constrictus** McCoy (Sect. A). Synop. Carb. Foss. Ireland, p. 181, Pl. 27, fig. 3. Mount. limest. Ireland.

1844. **Actinocr. costus** McCoy. Synop. Carb. Foss. Ireland, p. 181, Pl. 26, fig. 2; de Kon. and Lehon, 1853, Recher. Crin. Belg., p. 129, Pl. 3, figs. 2, a, b and Pl. 4, figs. a-d. Mount. limest. Ireland, and Tournay, Belg.

It seems very probable that **A. costus**, **A. lævis** and **A. tennuis** are synonyms.

1864. **Actinocr. Daphne** Hall (Sect. B). 17th Rep. N. York St. Cab. Nat. Hist., p. 52; also 1873, Geol. Rep. Ohio Paleont., ii, p. 162, Pl. 11, fig. 11. Waverly sandstone. Richfield, Ohio.

1843. **Actinocr. decadactylus** Portlock (not Goldf. = **Melocr. decadactylus**). Geol. Rep. Londonderry, p. 349. Mount. limest. Ireland.

1853. **Actinocr. deornatus** de Kon. and Lehon. Recher. Crin. Belg., p. 142, Pl. 3, figs. 5, a, b. Mount. limest. Tournay, Belg., and Wexford, Engl.

Probably **A. deornatus**, **A. stellatus**, **A. dorsatus**, and perhaps **A. icosidactylus** are synonyms.

1853. **Actinocr. dorsatus** de Kon. and Lehon. Recher. Crin. Belg., p. 139, Pl. 4, figs. 5 a, b; Meek and Worthen (Sect. A), Geol. Rep. Ill., ii, p. 149. Mount. limest. Tournay, Belgium.

*1869. **Actinocr. ectypus** Meek and Worthen. (**Strotocr. ectypus**). Proc. Acad. Nat. Sci. Phila., p. 159; also 1873, Geol. Rep. Ill., v, p. 253, Pl. 7, fig. 5. Lower Burlington limest. Burlington, Iowa.

This is a good **Actinocrinus**, the type specimen was depressed, and thereby had obtained an unnatural expression somewhat like **Strotocrinus**

1861. **Actinocr. excerptus** Hall (Sect. B). Desc. New Sp. Crin., p. 3; also, Bost. Jour. Nat. Hist., p. 276; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

A very doubtful species, probably *Syn.* of **A. proboscidialis.**

1860. **Actinocr. Fosteri** McChesney (Sect. B). Desc. New Pal. Foss., p. 19; also, 1867, Chicago Acad. Sci., p. 14, Pl. 5, fig. 2; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1860. **Actinocr. glans** Hall. Supp. Geol. Rep. Iowa, p. 16. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. tholus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 35.

Syn. **Actinocr. eryx** Hall, 1861. Desc. New Pal. Crin., p. 12.

This is a very variable species. The plates of the body in the lower layers at Burlington are scarcely convex, higher up, almost tuberculous, specimens of the former kind being described as **A. glans**, those of the latter as **A. tholus.** As **A. eryx** Hall redescribed a species of **A. glans** in which arms and anal tube were preserved, and in his photographic plates, which were distributed several years later, Hall unfortunately confounded his **A. eryx** (we examined the type specimen now in the Museum of Comparative Zoology at Cambridge), with **Megistocr. Whitei**, which has branching in place of simple arms, and no anal tube.

The species deviates somewhat in its general habitus from **Actinocrinus**, and we therefore place it here with some doubt.

1860. **Actinocr. Hurdianus** McChesney (Sect. B). Desc. New Pal. Foss., p. 24; also 1867, Chicago Acad. Sci., p. 17, Pl. 5, figs. 24; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1843. **Actinocr. icosidactylus** Portlock. Rep. on the County of Londonderry, p. 348, Pl. 15, fig. 7; de Kon. and Lehon, 1853, Recher. Crin. Belg., p. 141, Pl. 2, fig. 4 and Pl. 4, fig. 6. Mount. limest. Engl. and Belg.

1861. **Actinocr. infrequens** Hall (Sect. B). Desc. New Sp. Crin., p. 14; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1860. **Actinocr. jugosus** Hall (Sect. A). Supp. Geol. Rep. Iowa, p. 49. Lower portion of the Keokuk limest. Keokuk, Iowa, and Warsaw and Hamilton, Ill.

1821. **Actinocr. lævis** Miller (not Goldfuss nor Kloeden). Hist. of Crinoidea, p. 105, and plates; Agassiz, 1835, Mem. Soc. Neuchat., i, p. 196; Milne-Edwards, Anim. s. vert. de Lamk. (2^me^ ed.), vol. ii, p. 670; de Koninck, 1842, Anim. Foss. du Terr. Carb., p. 52, Pl. G, figs. 4 a, b, c; McCoy, 1844 (with doubt), Syn. Carb. Foss. Ireland, p. 182; de Kon. and Lebon, 1853, Recher. Crin. Belg., p 152, Pl. 3, fig. 6. Mount. limest. Tournay, Belg.

Syn. **Encrinus dubius** Schlottheim. Nachtr. Petref., ii, p. 100, Pl. 28, figs. 2 a, b.

1861. **Actinocr. limabrachiatus** Hall (Sect. B). Desc. New Sp. Crin., p. 2; also, Bost. Jour. Nat. Hist., p. 268; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1860. **Actinocr. lobatus** Hall (Sect. A). Supp. Geol. Rep. Iowa, p. 51; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Keokuk limest. Warsaw, Ill.

1869. **Actinocr. longus** Meek and Worthen (Sect. B). Proc. Acad. Nat. Sci. Phila., p. 156; also, Geol. Rep. Ill., v, p. 345, Pl. 8, fig. 1. Lower Burlington limest. Burlington, Iowa.

1858. **Actinocr. Lowei** Hall (Sect. A). Geol. Rep. Iowa, i. pt. ii, p. 611, Pl. 15, figs. 5 a, b; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Keokuk limest. Iowa and Illinois.

1861. **Actinocr. lucina** Hall (Sect. B). Desc. New Sp. Crin., p. 11. Lower Burlington limest. Burlington, Iowa.

1858. **Actinocr. multibrachiatus** Hall (Sect. B). Geol. Rep. Iowa, i, pt. ii, p. 580, Pl. 10, fig. 10; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

Syn. **A. multibrachiatus** var. **echinatus** Hall, 1861. Desc. New Pal. Crin., p. 10.

1857. **Actinocr. multiradiatus** Shumard (Sect. A). Trans. Acad. Sci. St. Louis, i, p. 7, Pl. 1, fig. 5; Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 579, Pl. 10, fig. 9; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Upper Burlington limest. Burlington, Iowa.

1861. **Actinocr. opusculus** Hall (Sect. B). Bost. Journ. Nat. Hist., p. 264; Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1849. **Actinocr. olla** McCoy (Sect. A). Ann. and Mag., p. 247. Mount. limest. Derbyshire, Eng.

1861. **Actinocr. ovatus** Hall (Sect. B). Desc. New Pal. Crin., p. 14; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1869. **Actinocr. penicillus** Meek and Worthen (Sect. A). Proc. Acad. Nat. Sci. Phila., p. 155; also, 1873, Geol. Rep. Ill., v, p. 342, Pl. 8, fig. 2. Lower Burlington limest. Burlington, Iowa.

1858. Actinocr. **pernodosus** Hall (Sect. A). Geol. Rep. Iowa, i, pt. ii, p. 608, Pl. 15, figs. 3, a, b; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Keokuk limest. Iowa and Illinois.

1821. Actinocr. **polydactylus** Miller (not Bonney = *Mariacr. pachydactylus* Hall, = *Melocr. pachydactylus* Wachsm. and Spr.). Hist. Crinoidea, p. 103; Agassiz, Mem. Soc. de Neuchat., i, p. 197; Milne-Edwards, 1836, Anim. s. vert. de Lamk. (ed. ii), vol. ii, p. 670; Bronn, 1836, Lethæa Geogn, i, p. 61, Pl. 4, fig. 4, and p. 670; Phillips, 1836, Geol. Yorkshire, ii, p. 206, Pl. 4, figs. 17, 18; de Koninck, Anim. Foss. Terr. Carb. Belg., p. 51, Pl. G, figs. 3, a, b; McCoy, 1844, Synop. Carb. Foss. Ireland, p. 183, and British Pal. Foss. Mus. Cambr., ii, p. 121; de Kon. and Lehon, 1853, Recher. Crin. Belg., p. 154, Pl. 4, fig. 2; Roemer, 1855, Lethaea Geogn. (Ausg. 3), p. 248. Mount. limest. Mendip Hills, Caldy, Ireland, and Tournay, Belg.

1858. Actinocr. **proboscidialis** Hall (Sect. B). Geol. Rep. Iowa, i, pt. ii, p. 584, Pl. 10, fig. 13; Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

Syn. A. **lagina** Hall, 1861. Desc. New Pal. Crin., p. 13.

Syn. A. **quaternarius** Hall, 1860. Supp. Geol. Rep. Iowa, p. 22.

Syn. A. **quaternarius** var. **spiniferus** Hall, 1861. Desc. New Pal. Crin., p. 11.

Syn. A. **themis** Hall, 1861. Ibid., p. 11.

1844. (?) Actinocr. **pusillus** McCoy. Synop. Carb. Foss. Ireland, p. 182, Pl. 26, fig. 4. Mount. limest. Ireland.

There is some doubt whether this species belongs to **Actinocrinus**; the rays are lobed but more like in species of **Dorycrinus**. Figure and description are too indistinct to ascertain therefrom the form of the anus.

1861. Actinocr. **reticulatus** Hall (Sect. B). Desc. New Spec. Crin., p. 2; also Bost. Journ. Nat. Hist., p. 269; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

Syn. A. **locellus** Hall, 1861. Desc. New Pal. Crin., p. 15.

Syn. A. **thoas** Hall, 1861. Ibid., p. 11.

1860. Actinocr. **scitulus** Meek and Worthen (Sect. A). Proc. Acad. Nat. Sci. Phila., p. 386; also Geol. Rep. Ill., ii, p. 202, Ibid., v, p. 341. Upper Burlington limest. Burlington, Iowa.

Syn. A. **rusticus** Hall, 1861. Desc. New Sp. Crin. p. 2; also Bost. Journ. Nat. Hist., p. 267.

Syn. A. **Sillimani** Meek and Worthen, 1861. Proc. Acad. Nat. Sci. Phila., p. 134.

Syn. A. **Wachsmuthi** White, 1861 (not 1879). Proc. Bost. Acad. Nat. Hist., vol. ix, p. 17.

1860. Actinocr. **sexarmatus** Hall (Sect. B). Supp. Geol. Rep. Iowa, p. 21; Meek and Worthen, Geol. Rep. Ill., v, p. 341, Photogr. Pl. 3, fig. 26. Lower Burlington limest. Burlington, Iowa.

Syn. A. **securus** Hall, 1861. Desc. New Pal. Crin., p. 14.

Syn A. **thetis** Hall, 1861. Ibid., p. 11.

1853. Actinocr. **stellaris** de Kon. and Lehon. Recher. Crin. Belg., p. 456, Pl. 3, figs. 3, a, b, and figs. 4, a-g; also Pl. 4, fig. 3; Pictêt, Traité de Paléont., iv, p. 323, Pl. 101, fig. 5. Mount. limest. Tournay, Belg.

Syn. A. **Gilbertsoni** de Koninck (not Miller nor Phillips). Anim. Foss. du Terr. Carb. de Belg., p. 50, Pl. G, figs. 2, a, b, c.

1853. Actinocr. **tennuis** de Kon. and Lehon. Recher. Crin. Belg., p. 128, Pl. 2 figs. 3, a, b. Mount. limest. Tournay, Belg.

1860. **Actinocr. tennuisculptus** McChesney (Sect. B). Desc. New Pal. Foss., p. 15; also Chicago Acad. Sci., 1867, vol. i, Pl. 5, fig. 11. Lower Burlington limest. Burlington, Iowa.

Syn. **A. chloris** Hall. Desc. New Sp. Pal. Crin., p. 3; also Bost. Journ. Nat. Hist., p. 275.

This species and **A. daphne** Hall, were placed by Meek and Worthen under Sect. A; but they belong more properly to Sect. B.

1836. **Actinocr. tessellatus** Phill. (Sect. B). Geol. Yorkshire, p. 206, Pl. 4, fig. 21. Mount. limest. Sommerset, Engl.

1861. **Actinocr. thalia** Hall (Sect. B). Desc. New Sp. Crin., p. 13; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1821. **Actinocr. triacontadactylus** Miller. Type of the genus. Hist. of the Crinoidea, p. 95, with five plates; Agassiz, 1835, Mém. Soc. de Neuchat., i, p. 196; Phillips, 1836, Geol. Yorkshire, p. 206, Pl. 4, figs. 12, 13; 1843, Portlock, Geol. Rep. Londonderry, p. 348; McCoy, 1844, Carb. Foss. Ireland, p. 182; Brit. Pal. Foss. Mus. Cambr., p. 121; De Kon. and Lehon, 1853, Recher. Crin. Carb. Belg., p. 131, Pl. 3, fig. 1; Roemer, 1855, Lethaea Geogn. (Ausg. 3), p. 248. Mount. limest. Yorkshire, Mendip Hills, near Bristol, Engl., and Tournay, Belg.

1853. **Actinocr. tricuspidatus** de Kon. and Lehon. Recher. Crin. Carb. Belg., p. 143, Pl. 2, figs. 5, a, b; Pictét, 1857, Traité de Paléont., iv, p. 323, Pl. 101, fig. 4. Mount. limest. Visé, Belg.

1860. **Actinocr. unicarinatus** Hall (Sect. A). Supp. Geol. Rep. Iowa, p. 48. Burlington and Keokuk. Transition bed (not Keokuk bed proper as given by Hall).

1858. **Actinocr. verrucosus** Hall (Sect. A). Geol. Rep. Iowa, i, pt. ii, p. 578, Pl. 10, figs. 7 a, b; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Upper Burlington limest. Burlington, Iowa.

Syn. **A. asterias** McChesney, 1860. New Pal. Foss., p. 9; also, 1867, Chicago Acad. Sci., vol. i, p. 9, Pl. 5, fig. 6.

1875. **Actinocr. viaticus** White (Sect. B). U. S. Surv. West of the 100th Meridian, under Wheeler, iv, Paleont., p. 82, Pl. v, fig. 1. (Preliminary Rep., 1874) Subcarbon. Nevada.

16. **TELEIOCRINUS** nov. gen.

(τέλειος, perfect; κρῖνον, a lily.)

Syn. *Actinocrinus* Hall (in part), 1858. Geol. Rep. Iowa, i, pt. ii, p. 590, and Ibid. Suppl, 1860.

Syn. *Calathocrinus* Hall, 1861 (not von Meyer, 1848). Subgenus of *Actinocrinus*. Desc. New Pal. Crin., p. 12.

Syn. *Strotocrinus* (Sect. B) Meek and Worthen. Geol. Rep. Ill., ii, p. 188.

The above name is proposed for a series of species, which were arranged by Meek and Worthen in a section under *Strotocrinus*, but which differ from the typical form of that genus in being provided with a long anal tube, instead of having a simple opening through the vault, as in their Sect. A. The form of the anus alone would warrant only a subgeneric division of the two groups, but there are other characters which have induced us to separate them generically.

In our general remarks upon the family, we have shown that Meek and Worthen's *Strotocrinus B*, for which we propose the genus *Teleiocrinus*, in all probability, sprung off from *Actinocrinus, Sect. B;* while Meek and Worthen's *Strotocrinus A*—their typical form—is similarly related to *Physetocrinus*, which we separate generically from *Actinocrinus*. The lateral rim, therefore, which produces the remarkable resemblance, according to our interpretation, in the form of *Strotocrinus* and *Teleiocrinus*, results from modifications in the one and the same direction, but which take place in different groups. We propose the following:—

Generic Diagnosis.—Body large; calyx urn-shaped, subconical below; the upper part, including the higher orders of radials, spread out horizontally, and formed into an extended, continuous rim around the body; vault moderately convex, with a strong subcentral anal tube; surface ornamentation similar to *Actinocrinus*, but, as a rule, very much coarser, the nodes more prominent than the striations, and sometimes almost entirely obscuring them.

Basals three, large, massive, projecting beyond the point of attachment for the column, and frequently extended into a bipartite node; sutures deep.

Primary radials 3 × 5; the first large, as high as wide; the second generally hexagonal, of the same proportions as the first but smaller; the third like the second, but angular above instead of truncate.

Secondary radials 1 × 10, axillary, supporting the two main divisions of the ray. The radials of all succeeding orders are composed respectively of a single series of pieces, of which only one plate, of each main division, in each order, bifurcates again, and this alternately on opposite sides, the other—opposite—plate which is never axillary, being succeeded in a direct line by a row of a variable number of fixed arm plates, which form branches within the body, alternately given off from the main trunks. All plates of the lateral branches and main divisions are closely joined with each other, and with those of the adjoining rays, and these together form the peculiar rim which surrounds the body. The plates of the rim are nearly of equal size, convex, and formed longitudinally into ridges, which give to the alternate branches the aspect of fixed arms, which they evidently are. Arm openings large and lateral, with a separate respiratory (?) pore to each opening.

Interradial, anal and interaxillary plates arranged as in *Actinocrinus*, and scarcely more numerous, they decrease in size upward, the upper ones are very minute.

Dome convex, in form of a ten-rayed star, indistinctly grooved between the arm bases. Vault constructed of larger and smaller pieces, which all decrease outward. The larger ones, which include the apical and all radial plates, are nodose or in part spiniferous; the smaller ones, including interradial and other accessory pieces are scarcely convex. The inner floor of the vault is strengthened by braces, which increase in thickness as they recede from the centre, and which, on approaching the rim, extend to the calyx, and from tunneled passages, one to each arm opening.

Column comparatively slender, composed of short, round joints, a part of which, at regular intervals, project out beyond the others, and send up and down, all around, at equal distances, five thickened processes or ribs, apparently as a natural provision to give it strength without destroying its flexibility. These processes give to the column a highly sculptured and somewhat pentagonal aspect, especially in its upper portions, where they are prominent and almost continuous vertically. But as these processes are only attached to the older and larger joints of the column, they gradually grow farther apart as they recede from the body, by the interpolation of the later developed joints, which increase in number downward. Some species, in place of five, have ten or more rows of processes along the column.

Perforation of medium size; pentalobate.

Geological Position, etc.—*Teleiocrinus* is limited to the Upper Burlington limestone, and is found only in America.

We place here the following species :—

*1859. **Teleiocrinus aegilops** Hall. (**Actinocr. aegilops**) Supp. Geol. Rep. Iowa, p. 5; Meek and Worthen, **Strotocr.** (B) **aegilops,** Geol. Rep. Ill., v, p. 349. Upper Burlington limest. Burlington, Iowa.

This is probably a younger stage of **Teleiocr. umbrosus.**

*1861. **Teleiocr. althea** Hall. (**Actinocr.—Calathocr.—althea**) Des . New Sp. Crin., p. 13, Photogr. Pl. 4, fig. 13. Upper Burlington limest. Burlington, Iowa.

*1861. **Teleiocr. clivosus** Hall. (**Actinocr. clivosus**) Bost. Journ Nat. Hist., p. 274. Upper Burlington limest. Burlington, Iowa.

*1861. **Teleiocr. erodus** Hall. (**Actinocr.—Calathocr.—erodus**) Desc. New Sp. Crin., p. 12; Meek and Worthen, **Strotocr.** (B), Geol. Rep. Ill., ii, p. 190. Upper Burlington limest. Burlington, Iowa.

*1861. **Teleiocr. insculptus** Hall. (**Actinocr.—Calathocr.—insculptus**) Desc. New Sp. Crin., p. 12; Meek and Worthen, **Strotocr.** (B), Geol. Rep Ill., v, p. 348. Upper Burlington limest. Burlington, Iowa.

*1861. **Teleiocr. liratus** Hall. (**Actinocr. liratus**) Supp. Geol. Rep. Iowa, Pl. 4, fig. 3; Meek and Worthen, **Strotocr.** (B) **liratus**, Geol. Rep. Ill., ii, p. 190; Ibid., v, p. 355, fig. 2. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. subumbrosus** Hall. Suppl. Geol. Rep. Iowa, p. 3.

*1860. **Teleiocr. rudis** Hall. (**Actinocr. rudis**) Supp. Geol. Rep. Iowa, p. 33. Upper Burlington limest. Burlington, Iowa.

*1861. **Teleiocr. tenuiradiatus** Hall. (**Actinocr. tenuiradiatus**, not 1847 = *Palæocystites tenuiradiatus.*) Desc. New Sp. Crin., p. 12; Meek and Worthen, **Strotocr.** (B) **tenuiradiatus**, Geol. Rep. Ill., v, p. 349. Upper Burlington limest. Burlington, Iowa.

*1858. **Teleiocr. umbrosus** Hall. (**Actinocr. umbrosus**) Type of the genus. Geol. Rep. Iowa, i, pt. ii, p. 590, Pl. 11, figs. 3 a, b; Meek and Worthen, **Strotocr.** (B) **umbrosus**, Geol. Rep. Ill., ii, p. 190; Ibid., v, p. 360, Pl. 8, fig. 5. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. delicatus** Meek and Worthen, 1869. Proc. Acad Nat. Sci. Phila., p. 156; also Geol. Rep. Ill., v, p. 343, Pl. 8, fig. 2.

This is described from a very young specimen of this genus, and exhibits most remarkably all the characteristics of **Actinocrinus.**

17. STEGANOCRINUS Meek and Worthen.

(Pl. 18, figs. 3, 4, 5.)

1866. Meek and Worthen. Geol. Rep. Ill., ii, p. 195.

1868. Meek and Worthen. Ibid., iii, p. 475.

1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 243.

1878. Zittel. (Subgenus of *Actinocrinus.*) Handb. der Palaeont., p. 370.

Syn. *Actinocrinus* (in part) Shumard, 1855, Geol. Rep. Missouri by Swallow, pt. ii, p. 189; Hall, 1858, Geol. Rep. Iowa, i, pt. ii, pp. 577, 582; Meek and Worthen, 1860, Proc. Acad. Nat. Sci. Phila., p. 387.

The relations of this genus with *Actinocrinus* and *Teleiocrinus* have been fully discussed in our general remarks upon the family.

Generic Diagnosis.—General form of the body like *Actinocrinus.* The rays extended into long tubular appendages, which bear the arms on both sides; dome with subcentral anal tube; surface ornamented by radiating ridges passing from plate to plate, and meeting in a small tubercle at the middle of each.

Basals three, forming a low cup. Primary radials 3 × 5, large; the first much larger than the others, hexagonal and heptagonal;

the second hexagonal, almost as high as wide; the third axillary, but smaller by half or more than the second, sometimes forming a part of the arm-like appendages, which in other species begin with the secondary radials. The secondary radials consist of 1 × 2 × 5 plates in each ray; sometimes both are axillary, and as such divide the ray into two equal sections, of which each one forms a separate tube, and gives off lateral arms from either side; in other cases only one is a bifurcating plate, which is the larger of the two, resting upon the wider side of the primary radials, while the other, which is smaller and obliquely given off, is truncate above, and supports an arm.

In the same manner other series of radials are given off from all succeeding radial plates, on one side a bifurcating plate bearing a higher order of radials, on the other a lateral arm, and this alternately from opposite sides (Pl. 18, fig. 3). The number of radials is to some extent indefinite, they extend to almost the height of the arms, which are long, and the ray itself terminates finally in a short arm. All the radials are of the same form, and nearly the same size, decreasing very gradually in an upward direction. They are wider than high, cuneate and alternately arranged, with the shorter side abutting against the side of the preceding arm, while the next arm is given off from the upper oblique side.

Arms long, of moderate thickness, constructed like those of *Actinocrinus*, beginning with one or two cuneate pieces, which soon turn into two series of alternate plates. Arm grooves deep; pinnules unknown.

Interradials three or more, those of the calyx forming a connection with the interradial plates in the dome. The posterior side, like that of all other *Actinocrinites*, consisting of a single special anal plate, which is in line with—and has the size of—the first radials; it supports two plates in the second, and generally three in the third series.

Vault highly elevated to moderately eonvex, composed of a variable number of pieces; centre and proximal dome plates not distinctly defined. The first radial dome plates, from which the brachial appendages begin, are spiniferous, and so alternately is one-half of the succeeding plates which cover the free rays. The covering of these appendages consists of two rows of plates, side by side, a larger and a smaller one, which are so arranged that at each side of the ray the larger plates alternate with the smaller ones, and the former abut laterally against an arm opening. The appendages are very heavy, composed of strong nodose plates; their cross-section, as that of their inner passage, oval, higher than wide (Pl. 18, fig. 5). At each side of the base of each arm, there is a respiratory (?) pore; that of one side is located at some distance from the arm openings, the other and smaller one lies close to it. The pores are so arranged that the larger ones stand at one side of the appendages in front, at the other behind the arm with which they are connected. Similar pores are placed beside the proximal arms, but these pass directly through the main body. Anal tube long, subcentral, composed of nodose pieces. Column round, of moderate size; central canal of medium width, pentalobate.

Geological Position, etc.—Steganocrinus, so far as known, is restricted to the age of the Burlington limestone, and has been found only in America.

We recognize the following species:—

1860. **Steganocrinus araneolus** Meek and Worth. (**Actinocr. araneolus**) Proc. Acad. Nat. Sci. Phila., p. 387; **Steganocr. araneolus**, 1866, Geol. Rep. Ill., ii, p. 198, Pl. 15, figs. 1 a, b. Lower Burlington limest. Burlington, Iowa.

*1855. **Steganocr. concinnus** Shumard. (**Actinocr. concinnus**) Swallow's Geol. Rep. Missouri, pt. ii, p. 189, Pl. A, fig. 5; Meek and Worth., 1866, **Actinocr. concinnus**, Geol. Rep. Ill., p. 200, Pl. 15, figs. 9 a, b. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. validus** Meek and Worthen, 1860, Proc. Acad. Nat Sci. Phila. p. 384.

1858. **Steganocr. pentagonus** Hall. Type of the genus. (**Actinocr. pentagonus**) Geol. Rep. Iowa, i, pt. ii, p. 577, Pl. 10, figs. 6 a, b; Meek and Worthen, 1866, **Steganocr. pentagonus**, Geol. Rep. Ill., ii, p. 198; Ibid., 1868, iii, p. 474, Pl. 16, fig. 8. Lower Burlington limest. Burlington, Iowa.

1858. **Steganocr. sculptus** Hall. (**Actinocr. sculptus**—not Miller) Geol. Rep. Iowa, i, pt. ii, p. 582, Pl. 10, figs. 11 a, b; Meek and Worthen, 1866, **Steganocr. sculptus**, Geol. Rep. Ill., ii, p. 198. Lower Burlington limest. Burlington, Iowa.

18. AMPHORACRINUS Austin.

1848. Austin. Quart. Journ. Geol. Soc. London, iv, p. 292.
1873. Meek and Worthen. Geol. Rep. Ill., v, p. 386.
Not Roemer, 1855. Lethæa Geogn. (Ausg. 3), p. 250 = *Agaricocrinus.*
Not Hall, 1861. Bost. Journ. Nat. Hist., p. 561 = *Agaricocrinus.*
Not Meek and Worthen. Geol. Rep. Ill., ii, p. 209 = *Dorycrinus.*
Syn. *Amphora.* Cumberland, 1826. Reliqu. Conserv., p. 26.
Syn. *Actinocrinus* Phillips (in part), 1836. Geol. Yorkshire, p. 206.
Syn. *Actinocrinus* Hall (in part), 1860. Supp. Geol. Rep. Iowa.

Cumberland proposed in 1826 the name *Amphora* for two very distinct species, which were distinguished by him by numbers. His species No. 1, represents a lobed species of *Actinocrinus* Miller, while his No. 2 is *Amphoracr. Gilbertsoni* Austin. Cumberland's descriptions of the genus (?) *Amphora*, were evidently taken from his first species, for he describes it as resembling in outer form " a wine *Amphora* with five handles for suspension and a central neck to pour from," which applies well only to Pl. C, fig. 5. This species must therefore be considered the type of *Amphora* if taken in a generic sense, but being a species of *Actinocrinus*, the name became a synonym, and Austin was perfectly at liberty to remodel it into *Amphoracrinus*, or even propose an entirely new name. Austin's *Amphoracr. crassus* and *A. granulosus*, which were mentioned in connection with the genus, have never been defined. Goldfuss, in 1848, used the name in a specific sense, not being aware that Phillips had already, in 1836, adopted for Cumberland's " *Amphora* No. 2 " Miller's MS. name " *Gilbertsoni*."

Roemer and Hall have both confounded *Amphoracrinus* with *Agaricocrinus*, with which the form of the body has a slight resemblance, but from which it differs materially in the arrangement of plates; in having the radials laterally extended; in the subcentral anal tube, and also in the arm structure.

Meek and Worthen at first brought *Amphoracrinus* into connection with *Dorycrinus* Roemer, from which it differs as much as from *Agaricocrinus*. *Dorycrinus* has delicate arms, arranged in pairs, a comparatively deep calyx, and a lateral anal opening.

Amphoracrinus is a somewhat aberrant form, but its closest affinities are evidently with the *Actinocrinites*, with which it agrees in the lobed form of the body, in the general structure of the vault, in the arrangement of the anal plates, and in the position of the anal tube; while in the depressed form of the calyx it resembles the *Agaricocrinites*, and in the arms it is somewhat like the *Periechocrinites*.

Generic Diagnosis.—Body higher than wide, decidedly lobed; symmetry bilateral. Calyx short, composed of comparatively few plates, lower portions, up to arm bases, from saucer-shaped to slightly convex, but never concave. Dome highly elevated, and somewhat inflated, especially toward the posterior side, which is extended into a subcentral or excentric anal tube. Surface of body plates, including dome, covered with peculiar granules or indistinct wrinkles.

Basals three, moderately large, forming together a shallow hexagonal basin, the upper side without re-entering angles; a low rim borders the columnar facet. Primary radials 3 × 5; the first wider than high, much narrower at their junction with the basals, superior lateral sides short; second radials generally shorter than the first, but wider; third radials wide, as high as the second; the second are arranged horizontally to the vertical axis of the body, while the third sometimes take even a downward direction. In the European species only the secondary radials assume that position; in American species the convexity of the calix does not extend beyond the first radials. The upper radials bend so abruptly outward, that only their lower corners come in contact with the interradials, the plates themselves form the base of a lobed lateral extension; contrary to *Agaricocrinus*, in which they are flattened out, and form a disk in connection with the adjoining pieces.

Secondary radials 1 × 10, either all bifurcating, or one side of each ray only. In the former case, each plate supports on each of its sloping sides a tertiary radial, which in turn supports the primary arms; in the other, one arm is given off from a secondary radial. The rays, to the base of the arms, are spread out horizontally, and the arms curve upward very gradually; this gives to the specimen, with the arms attached, an unusually broad appearance, its width and length being almost equal. Arms cylindrical, strong, of nearly equal size to their full length, divergent, simple or ramifying, composed of two series of very narrow pieces, alternately arranged, rounded at the back, with zigzag suture lines. In *A. spinobrachiatus* Hall, in which the arms on becoming free remain simple, some of the joints at each side of the arm are extended into long lateral spines, which stand out conspicuously from both sides of the arm bases. The lower ones are short, but they increase in length upward until they attain a length of one and one-half the width of the arm. The spines are placed farther apart as they increase in size, the distance being lengthened each time by one additional joint. In species in which the arms divide, the joints are smooth, and the bifurcation takes place from the double-jointed arms, as in the case of *Periechocrinus*, not from single plates as in *Platycrinus*, etc.

Interradials three, of moderate size, the two upper ones situated within the sinus formed by the extended rays. Anals three to four large ones, succeeded by additional smaller ones; the first in line with the first radials; the second series two, rarely three. In the construction of the anal side, *Amphoracrinus* forms a link between the *Actinocrinites* and *Agaricocrinites*. In this respect it is interesting to observe that the second series of plates, within the limits of the same species, has sometimes two, and sometimes three plates, but wherever the third plate is present, it is narrower and smaller, and touches the first anal but slightly; while when absent, the plate above them falls in deeply between the two plates.

Dome high, inflated, the interradial spaces depressed, the radial portions formed into broad ridges, which increase in prominence toward the arm bases. Central dome, and the four large proximal pieces placed in contact with each other, large, and strongly spiniferous (the spines in *A. divergens* Hall sometimes attain a length of an inch and a-half, and are bi- or tri-digitate), the two smaller proximal plates are separated by a wide, somewhat inflated area, which supports an anal tube. The tube is located in the rear of the central plate and is almost central, while the central plate is pushed somewhat to the anterior side. The tube is constructed of plates similar to those of the vault; it is rather stout throughout, but very short, its upper extremity rounded, with a small subcentral anal opening, which is surrounded by plates and spines, similar to those which surmount the vault at the base of the tube, but on a smaller scale. The other plates of the dome are of nearly equal size, their surface beautifully granulated. Inner floor of the vault as in *Actinocrinus*, deeply grooved along the radial portions, and formed into closed galleries toward the arm bases.

Column round, constructed alternately of larger and smaller joints, whose lateral margins are sharply edged; central canal small.

Geological Position, etc.—*Amphorocrinus* occurs only in the lower strata of the Subcarboniferous—not beyond the age of the *Lower* Burlington limestone—both in America and Europe.

We recognize the following species:—

*1849 (?). **Amphoracrinus atlas** McCoy. (**Actinocr atlas**) Ann. and Mag. Nat. Hist. (ser. ii), vol. iii, p. 246; Roemer, 1855, **Amphoracr. atlas**, Lethæa Geogn. (Ausg. 3), p. 250. Mount. limest. Bolland, Engl.

Perhaps *Syn.* of **Amphoracr. Gilbertsoni** Austin.

1860. **Amphoracr. divergens** Hall. (**Actinocr. divergens**) Supp. Geol. Rep., Iowa, p. 36; Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 388, Pl. 6, fig. 6. Lower Burlington limest. Burlington, Iowa.

Syn. **Amphoracr. divergens** var. **multiramosus** Meek and Worth., 1873. Geol. Rep. Ill., v, p. 389, Pl. 6, fig. 6.

Syn. **Amphoracr. planobasilis** Hall, 1860. Supp. Geol. Rep. Iowa, p. 19, Pl. 4, figs. 10, 11; **Amphoracr. planobasilis** Meek and Worth., 1873, Geol. Rep. Ill., v. p. 388.

Syn. **Actinocr. quadrispinus** White. Proc. Bost. Soc. Nat. Hist., ix, p. 15; **Amphoracr. quadrispinus** Meek and Worthen. Geol. Rep. Ill., v, p. 388.

1821. **Amphoracr. Gilbertsoni** Miller (not de Koninck). Type of the genus.. **Actinocr. Gilbertsoni** (Philips, 1836, Geol. of Yorkshire, p. 206, Pl. 4, fig. 19; Austin, 1842, Ann. and Mag. Nat. Hist., x, p. 109; **Amphoracr. Gilbertsoni.** Quart. Journ. Geol. Soc. London, iv, p. 292; Bronn, 1860, Klassen d. Thierreichs, ii, Pl. 28, fig. 2; Quenstedt, 1862, Handb. d. Petref., p. 619, Pl. 54, figs. 24 a, b. Subcarboniferous. Florence Court, Ireland.

Syn. **Amphora No. 2.** Cumberland, 1826, Reliquiæ Conservata, p. 36.

Syn. **Melocr. amphora** Goldfuss, 1838. Nova Acta Ac. Leop., xix, p. 341.

Syn. **Actinocr. amphora** Portlock, 1843. Rep. Geol. Londonderry, Pl. 20, figs. 4 a, and 5 a, b; McCoy, 1844, Synops. Pal. Foss. Ireland, p. 181.

1860. **Amphoracr. spinobrachiatus** Hall. (**Actinocr. spinobrachiatus**) Supp. Geol. Rep. Iowa, p. 6; Meek and Worthen, 1873. **Amphoracr. spinobrachiatus**, Geol. Rep. Ill., v, p. 388, Pl. 6, fig. 5. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. inflatus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 20, (not **Actinocr.** (**Amphoracr.**) **inflatus** Hall, 1861 = **Agaricocr. inflatus**); Meek and Worthen, 1873, **Amphoracr.** (?) **inflatus**, Geol. Rep. Ill., v, p. 388. Lower Burlington limest. Burlington, Iowa

*1864. **Amphoracr. viminalis** Hall (**Actinocr. viminalis**). 17th Rep. N. York St. Cab. Nat. Hist., p. 54; Geol. Rep. Ohio, Paleont., ii, p. 165, Pl. 11, figs. 12–14. Waverly gr. Richfield, Ohio.

19. **PHYSETOCRINUS** Meek and Worthen.

(Pl. 19, fig. 5).

1869. Meek and Worthen (subgenus of *Strotocriuus*). Proc. Acad. Nat. Sci. Phila., p. 158.

1873. Meek and Worthen. Geol. Rep. Ill., V, p. 349.
(Described by Hall under *Actinocrinus.*)

Physetocrinus was proposed by Meek and Worthen as a subgenus of *Strotocrinus*, on account of its close affinities with their *Strotocrinus* Sect. A, both having a simple anal opening through the vault. They thus separate *Physetocrinus* generically from *Actinocrinus*, but they place *Strotocrinus* and our *Teleiocrinus*, although these differ in the same characters, as mere sections under the same generic form. Meek and Worthen evidently made the rim the criterion for the generic division. This we acknowledge to be a good character, but it must not be used to unite two groups, otherwise distinct, in which the rim has been independently developed, by modifications under similar conditions.

Physetocrinus differs from *Actinocrinus* in the form and construction of the vault, in having no anal tube; in having pores along the radial portions of the dome, and in possessing no hook-like projections along the pinnules.

Generic Diagnosis.—Body large, wider than high; calyx semi-ovate, much higher than the dome, which is depressed, convex, or almost straight; plates ornamented with beautiful striæ and with a deep indentation at each corner of the plates.

Basals three, large, truncate below, projecting out from the body, and forming together a low cup. Primary radials 3 × 5, of nearly equal size, the upper supporting 1 × 2 × 5 comparatively large secondary radials, which all bifurcate and support the two main divisions of the ray. These extend out from the body, and throw off on both sides lateral branches from each plate as in *Actinocrinus*, which on becoming free turn into arms. The five main rays, their divisions, and every branch, are separated by small pieces, which toward the arm bases form deep sinuses, extending deeply into the vault, and giving to the surface that corrugated aspect which is so characteristic of this genus.

Interradial plates more numerous than in *Actinocrinus;* they consist of one in the first, and two in each succeeding series, gradually decreasing in size. The upper plates, which are minute, join with the plates of the vault, to form the depressions between the main rays. There are three, five, or more interaxillary pieces, which, connecting with the vault, form the sinuses between the main division of the ray, while one or more interbrachial plates, in a similar manner, separate the lateral branches.

Anal area somewhat wider, and the sinus between the adjoining rays a little deeper than in the other four interradial fields; it is composed of one large special plate in line with the first radials, two smaller plates in the second, and generally three plates in the succeeding series.

Vault composed of rather delicate, extremely small tuberculous pieces, which are disposed apparently without order or regularity; only the proximal dome plates being distinguishable. There are small braces on the inner side of the floor, and the entire vault is bent so as to form, in connection with the braces, in the interradial and interbrachial spaces, natural ridges, which at the inner side constitute grooves or open galleries for the reception of the ambulacral tubes. It is a remarkable feature of this genus, that the inner floor within the grooves is lined with indentations, which evidently formed passages through the vault, perhaps in connection with the hydrospires, and either communicated with the surrounding element or with soft appendages. These indentations have been observed only in *Physetocrinus* and *Strotocrinus* (not *Teleiocrinus*), but in several species, and hence may be considered a good generic distinction. They are located between the sutures along the middle series of plates, and are best observed in natural casts (Pl. 19, fig. 5), in which they form little tubercles, which extend to the arm bases.

Anus in form of a circular opening through the vault, surrounded by very minute plates, which were somewhat flexible, for they bulge out frequently into a small protuberance.

Arms long, the sides somewhat angular; constructed of two series of pieces; pinnules composed of slender joints (without hooks), closely arranged.

Column like that of *Actinocrinus*.

Geological Position, etc.—*Physetocrinus* has been discovered only in America, and in rocks of the age of the Burlington limestone.

We recognize the following species:—

1869. **Physetocrinus asper** Meek and Worthen. (**Strotocr.—Physetocr.—asper**) Proc. Acad. Nat. Sci. Phila., p. 161; also Geol. Rep. Ill., v, p. 351, Pl. 7, fig. 1. Upper Burlington limest. Burlington, Iowa.

1869. **Physetocr. dilatatus** Meek. (**Strotocr.—Physetocr.—dilatatus**) Proc. Acad. Nat. Sci. Phila., p. 162; also Geol. Rep. Ill., v, p. 363, Pl. 10, fig. 6. Upper Burlington limest. Burlington, Iowa.

1858. **Physetocr. ornatus** Hall. (**Actinocr. ornatus**) Geol. Rep. Iowa, i, pt. ii, p. 583, Pl. 10, fig. 12; Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 349. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. senarius** Hall, 1860. Supp. Geol. Rep. Iowa, p. 25.

1858. **Physetocr. ventricosus** Hall. Type of the genus. (**Actinocr. ventricosus**) Geol. Rep. Iowa, i, pt. ii, p. 595, Pl. 11, figs. 6 a, b; Meek and Worthen, Geol. Rep. Ill., v, p. 349. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. ventricosus** var. **internodius** Hall, 1861. Desc. New Sp. Crin., p. 3; also Bost. Journ. Nat. Hist., p. 278.

Syn. **Actinocr.** var. **reticulatus** 1861. Desc. New Sp. Crin., p. 3.

Syn. **Actinocr.** var. **cancellatus.** Bost. Journ. Nat. Hist., p. 279.

Syn. **Actinocr. subventricosus** McChesney, 1860. New Pal. Foss., p. 21; also 1869, Chicago Acad. Sci., i, pt. i, p. 16, Pl. 4, fig. 6; Meek and Worthen, Geol. Rep. Ill., v, p. 349.

20. STROTOCRINUS Meek and Worthen.

(Pl. 18, figs. 1, 2.)

1866. Meek and Worthen (in part, Sect. A). Geol. Rep. Ill., ii, p. 188.
1866. Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 253.
1869. Meek and Worthen. Ibid., p. 158.
1873. Meek and Worthen. Geol. Rep. Ill., v, p. 347.
1878. Zittel. (Subgenus of *Actinocr.*) Handb. d. Palæont., p. 370.

Syn. *Actinocrinus* (in part) Hall, 1860 and 61; Meek and Worthen, 1861.

Syn. *Calathocrinus* Hall. (Subgenus of *Actinocrinus.*) 1861, Desc. New Sp. Crin., p. 12 (not von Meyer, 1848).

The relations of this genus with *Teleiocrinus*—Meek and Worthen's *Strotocrinus* B—have been sufficiently discussed, also with *Physetocrinus*, and so we offer without remarks our

Revised Generic Diagnosis.—Body extremely large, the lower portions conical, the upper spread horizontally, forming a continuous rim surmounting the cone; dome flat or slightly convex, without anal tube; surface of plates beautifully striated.

Basals three, large, of equal size, forming a cup which is truncate below. Primary radials 3 × 5; the first larger, higher than wide; second and third of nearly equal size. The third radials give off 1 × 2 × 5 secondary radials, all bifurcating plates, which form the bases of the two main divisions of the ray. These and all succeeding plates are spread out horizontally, and form a part of the rim.

The succeeding orders of radials are composed of 1 × 2 plates to each main division of the ray, one of them always axillary, the other truncate above. The former gives off the next number of radials, while the latter is succeeded by a number of fixed arm plates which form lateral branches and give off finally the free arms. The radials are so arranged that in each succeeding order, and these are numerous, the bifurcating plate is placed always to the opposite side, so that the branches are given off alternately from opposite sides like pinnules. The two main trunks of each ray extend in length beyond the branches, and as both, the main trunks and branches, are marked along the median line by a conspicuous ridge or elevation, passing from plate to plate, the branching of the rays in the rim is most beautifully indicated. In the formation of the rim, the interradial and interaxillary plates also contribute, and these extend frequently to near the free arm bases.

The lateral branches either abut against each other or are partly separated by small pieces, which, as we suggested, are rudiments of early pinnules.

Interradials, anals, and interaxillary plates arranged as in the preceding genus, but they are more numerous, and, contrary to *Teleiocrinus*, extend far into the rim.

Vault depressed, convex or more frequently flat, and only near the arm bases somewhat rounded, the spaces along the ten main divisions somewhat elevated above the general plane. The disk is paved by many hundreds of small polygonal pieces, which decrease in size toward the arms, and which at the outer points of the rays become almost microscopic. The apical plates are larger, and are separated from each other, but not otherwise distinguished from the other plates, and hence are not easily identified.

Anus in form of a simple opening through the vault. The inner floor of the vault is constructed similar to that of *Physetocrinus*, and has similar indentations (pores?) along the grooves; but the divisions of the ray, within the rim, are separated as in *Teleiocrinus* by partitions, and thus are formed into regular ducts, which diverge until there is a separate passage to each ray. Arm openings laterally arranged around the rim, each one with a respiratory(?) pore aside of it. Arms long, comparatively thin, not bifurcating in their free state; pinnules long, composed of slender joints.

Column round, not large in proportion to the size of the specimen, without external rips or thickened processes; central canal of medium size, pentagonal.

Geological Position, etc.—*Strotocrinus* seems to be limited to the Subcarboniferous of the Mississippi valley, and is here found only in a small belt at the middle portion of the Upper Burlington limestone, where it seems to have flourished in great profusion, but none reached up to the Keokuk Transition bed.[1] The two or three species of this genus belong to the largest and most beautiful forms of the Palæocrinoidea, the body without arms attains sometimes a height of five inches by six inches width along the rim, the latter spread out an inch and more all around, while the main branches reach a length of two inches and a-half.

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[1] The species which S. A. Miller describes from Bloomfield, Mo., under *Strotocr. Bloomfieldensis* is from cherty layers of the Upper Burlington, and not from the Keokuk limestone; we take it to be a synonym of *Strotocr. regalis* until specimens showing the test prove the contrary, a diagnosis based upon the internal cast only, has in our opinion very little value.

We place here the following species:—

1859. **Strotocrinus glyptus** Hall. (**Actinocr. glyptus**) Supp. Geol. Rep. Iowa, p. 2; Meek and Worthen, **Strotocr. glyptus** (Sect. A), Geol. Rep. Ill., ii, p. 190. Upper Burlington limestone. Burlington, Iowa. This is not a *Syn.* of **Actinocr. erodus** Hall as supposed by Meek and Worthen.

1859. **Strotocr. perumbrosus** Hall. (**Actinocr. perumbrosus**). Supp. Geol. Rep. Iowa, p. 7; Meek and Worthen, **Strotocr. perumbrosus** (Sect. A), Geol. Rep. Ill., ii, p. 190; also Ibid., v, p. 357, Pl. 8, fig. 4. Upper Burlington limest. Burlington, Iowa. This is probably a *Syn.* of **Strotocr. regalis.**

1859. **Strotocr. regalis** Hall. (**Actinocr. regalis**) Supp. Geol. Rep. Iowa, p. 8; Meek and Worthen, 1866, **Strotocr. regalis**, Geol Rep. Ill. ii, p. 192. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. speciosus** Meek and Worthen, 1860, Proc. Acad. Nat. Sci. Phila., p. 386. (Meek acknowledged it to be a *Syn.* of **Strotocrinus regalis** in 1866).

Syn. **Strotocr. Bloomfieldensis** S. A. Miller, 1879, Jour. Cincin. Soc. Nat. Hist., vol. ii, Pl. 15, fig. 6.

21. GENNÆOCRINUS. Nov. Gen.

(*γενναῖος*, of noble origin, *κρῖνον*, a lily).

We propose the above name for a little group of Crinoids from the Upper Devonian, which cannot be satisfactorily referred to any established genus. In their general construction they closely resemble *Actinocrinus* and *Physetocrinus*, but differ from both, and in fact from all Actinocrinites, in the arrangement of the anal plates. The anal area has in the second series, like all other Actinocrinidæ, previous to the Subcarboniferous, three plates in place of two, agreeing therein with the Batocrinites, from which they differ, however, in the much greater number both of anal and interradial plates, the different arrangement of these plates, which form an unbroken line with the interradial vault pieces, the presence of interaxillaries, the strongly lobed form of the body, the mode of bifurcation, and in other characters. It is possible when the construction of the vault and arms are better known, that *Gennæocrinus* should be placed subgenerically either under *Actinocrinus* or *Physetocrinus.*

Generic Diagnosis.—General form of body wider than high, lobed at the arm regions; calyx beautifully striated, the higher radials formed into ridges and resembling fixed arms; vault low hemispherical, composed of small, spiniferous or nodose plates.

Basals three, short, with a tripartite rim formed by the projection of the lower margin of the plates. Primary radials 3 × 5, of nearly similar form but decreasing in size upward. The third radial gives off 1 × 10 secondary radials, and these form the two main trunks, of which each one gives off, alternately throughout all the bifurcations, and from every first joint, an axillary, and to the opposite side a fixed arm plate, the one supporting the next order of radials, the other being succeeded by additional arm plates, which on becoming free, pass into a simple arm.

Interradials numerous, from five to seven or more, the second resting between the second and third primary radials, the upper ones being in contact with the interradial plates. The space between the rays is wide, deeply depressed, especially at the posterior side, and this depression extends to the vault. Anal area very wide, the first plate in line with the first radials, and of their size. There are two plates in the second range, three or four in the third, with a large number of small pieces above, which imperceptibly connect with the plates of the vault.

Interaxillary plates one to three. Vault depressed its radial portions formed into ridges or lobes, which rapidly increase in prominence toward the arm regions. It is composed of moderately small, apparently irregularly arranged pieces, which are more or less spiniferous.

Anus excentric, probably in form of a simple opening through the vault. Arms unknown.

Geological Position, etc.—*Gennæocrinus* is restricted to the Hamilton group of America.

We place here the following species:—

*1862. **Gennæocrinus calypso** Hall. (**Actinocr. calypso**) 15th Rep. N. York, St. Cab. Nat. Hist., p. 133. Hamilton gr. Western N. Y.

*1861. **Gennæocr Cassedayi** Lyon. (**Actinocr. Cassedayi**) Proc. Acad. Nat. Sci., Phila., p. 410, Pl. 4, figs. 3, 3a. Encrinal limest. Near Lousville, Ky.

*1862. **Gennæocr. cauliculus** Hall. (**Actinocr. cauliculus**) 15th Rep. N. York, St. Cab. Nat. Hist., p. 132. Hamilton gr. Western N. York.

*1862. **Gennæocr. eucharis** Hall. (**Actinocr. eucharis**) 15th Rep. N. York, St. Cab. Nat. Hist., p. 130. Hamilton gr. Western N. York.

*1860. **Gennæocr. Kentuckiensis** Shumard. Type of the genus. (**Actinocr Kentuckiensis**) Am. Journ. Sci. and Arts. (ser. 2), vol. 28, Septbr. 1859, p. 238, Cat. Pal. Foss., p. 345. Lower part of Hamilton gr. Beargrass Quarries, near Louisville, Ky.

Syn. **Actinocr. cornigerus** Lyon & Cass., 1859.(not Hall, 1858).

*1862. **Gennæocr. nyssa** Hall. (**Actinocr. nyssa**). 15th Rep. N. York. St. Cab. Nat. Hist., p. 129. Hamilton gr. Western N. York.

*1862 (?) **Gennæocr. pocillum** Hall. (**Actinocr. pocillum**). 15th Rep. N. York. St. Cab. Nat. Hist., p. 134. Hamilton gr. Western N. York. (This species probably belongs to some other group.)

f. BATOCRINITES.

22. BATOCRINUS Casseday.

(Pl. 18, fig. 8 and Pl. 19, fig. 2).

1854. Casseday. Deutsche Zeitschr. d. Geol. Gesellsch., vi, p. 237.
1857. Pictét. Traité de Paléont., iv, p. 324.
1865. Meek and Worthen (Subgen. *Actinocr*). Proc. Acad. Nat. Sci., Phila., p. 153.
1866. Meek and Worthen (Subgenus of *Actinocr.*). Geol. Rep., Ill., ii, p. 150.
1869. Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 350.
1873. Meek and Worthen. Geol. Rep., Ill., v, p. 364.
1878. Wachsm and Spr. Proc Acad. Nat. Sci., Phila., p. 329.
1879. Zittel (Subgenus of *Actinocr*). Handb. Palæont., p. 370.
Syn. *Actinocrinus* (in part), Shumard, Hall, White, McChesney, Meek and Worthen (prior to 1865).
Syn. ***Uperocrinus.*** Meek and Worthen, 1865 (Subgenus of ***Batocrinus.*** Proc. Acad. Nat. Sci., Phila., p. 153.

The generic distinctions between *Batocrinus* and *Actinocrinus* have been fully discussed in our remarks upon *Actinocrinus*, but it remains yet to note the somewhat different mode in which the arms increase in the two groups. We describe below two new species of *Batocrinus* and three of *Eretmocrinus*, from which it appears that in these genera, and in the *Batocrinites* generally, the increase of arms, from one species to another, is not gradually, by the addition of a single arm to each ray, as in the case of *Actinocrinus*, but by duplicating the entire number of arms throughout the species.

Meek and Worthen in 1866, in adopting *Batocrinus* as a genus, separated it into subgenera, and again subdivided the typical form into two sections : " A, species in which the arm openings are directed outward ; B, in which they are directed upwards, and arranged, more or less, into groups." The position of these openings had evidently no important bearing upon the general structure of the crinoid, only that in the former the ambulacral passages entered horizontally, in the others obliquely, and this difference is caused by the greater or less degree of prominence developed in the uppermost ring of radials.

The name *Uperocrinus*, in a subgeneric sense, was proposed by Meek and Worthen for species with a narrow calyx, drawn out so as to form a kind of handle for the upper portions, but was given up afterwards.

Generic Diagnosis.—General form of body biturbinate, wheel-shaped, or globose; calyx and vault of a similar form, the former composed of smooth, slightly convex to strongly nodose plates, scarcely ever striated; the dome consisting of convex or tuberculous pieces, with a strong, almost central anal tube. Symmetry of calyx bilateral.

Basals three, equal, not very high, forming an extended rim with a concavity for the reception of the column. Primary radials 3 × 5; the first hexagonal or heptagonal, larger than the second and third combined; the second quadrangular, linear, always narrower than the first, but yet twice or three times wider than high, sometimes altogether anchylosed with the third; the third pentangular, short, the lower lateral sides abruptly spreading and giving a greater width to the median portions, the upper sides supporting the higher radials. Secondary radials 2 × 10, very wide, as large as the primary ones; those of the second series bifurcating. The anterior ray has sometimes but two or three arms, this is frequently accidental, but in some species the rule. Tertiary radials 2 × 2 × 10, narrower than the secondary, supporting the arms.

In some species the posterior rays support additional plates in the body, but only in the division next to the anal area, this side sometimes having one, two or three additional arms, while the opposite division retains the usual number of four. The upper row of plates is at the outer face truncated for the reception of the arms, their upper sides being notched along the median portions for the arm passages. This notch is joined by a similar notch in the corresponding plates of the dome, which, combined with the other, forms an arm opening (Pl. 19 , fig. 2, and Pl. 18, fig. 8); the opening is oval in form, longer than wide, resting within the centre of a small concavity. The part which extends into the vault, follows the lateral edges of a tertiary radial dome plate. The opposite side of the radial is likewise excavated to receive a respiratory (?) pore, which is enclosed on the other side by an adjoining interradial or interbrachial piece. Hence the two openings are separated by the tertiary radial dome plates, whose width varies in different species, and according to the position which the arm occupies within the ray (Pl. 18, fig. 8). Whenever the respiratory (?) pore is in connection with the arms of the inner part of the ray, it is placed closer to the arm opening than pores which are placed toward the outer side. The respiratory (?) pores in the *Batocrinites* are exceptionally large, sometimes attaining a width equal to one-third that of the arm opening. Their connection with the inner cavity has been explained elsewhere.

The interradials of the calyx are not numerous, varying from one to four or five, but rarely exceeding three. The first very large, polygonal, nearly as large as the primary radials; it rests between the upper edges of the first radials, between the second, and against the lower sloping edges of the third, and is followed by two or three very much smaller pieces. The anal area has one plate in line with the first radials, of about their size; there are three plates in the second series, and a few more small pieces above. None of the plates of the interradial or anal series connect with the dome, from which the interradial area of the calyx is separated by the tertiary radials, which meet all around laterally. There are no interaxillary plates, except in the case of *B. planodiscus* and occasionally in *B. trochiscus*, in which the arm regions are spread out in width to three times the height of the body. This species has also a greater number of interradials.

Vault elevated, composed of comparatively large and heavy pieces, of nearly equal size, even the apical plates, with the exception of the central plate, being but little larger than the rest. The centre piece and the proximal dome plates are much crowded toward the anterior side, owing to the nearly central anal tube, of which, on that side, the large central plate forms the base. The tube is constructed of similar plates as the vault, and very long, sometimes extending more than twice the length of the arms beyond their tips, it is very straight in all cases, and tapers gradually almost to a point, with a narrow passage at the upper end.

Arms from eighteen to twenty-six, or thirty-six to forty, either in pairs or single from each arm opening, round, very short, of medium size and equal width throughout their length. From the body up, they are composed of two series of alternate pieces, and in species which have the double arm structure, the first of these joints, without increasing in height, gives off, in place of the first pinnule in the other species, a second arm, which passes into the same arm opening as its companion. Pinnules composed of slender joints, closely attached laterally, their sides flattened, their depth greater than their width, with a deep ventral furrow covered by small plates.

Column round, composed of rather large joints with more or less angular edges; perforation of moderate size, pentangular.

Geological Position, etc.—*Batocrinus* is strictly a Subcarboniferous form. It is exclusively an American genus, and embraces the last survivors of the Actinocrinidæ.

We place here the following species:—

*1860. **Batocrinus æquibrachiatus** McChesney. (**Actinocr. æquibrachiatus**) New Pal. Foss., p. 25; also Chicago Acad. Sci., 1867, p. 18; Meek and Worthen, 1873, **Batocr. æquibrachiatus**, Geol. Rep. Ill., v, p. 368. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. asteriscus** Meek and Worthen, 1860. Proc. Acad. Nat. Sci. Phila., p. 385; also 1866, Geol. Rep. Ill., ii, p. 207, Pl. 15, figs. 8 a, b, c; also 1873, **Batocr. asteriscus**, Ibid., v, p. 368.

Syn. **Actinocr. æquibrachiatus** var. **alatus** Hall. Desc. New Spec. Crin., 1861; also Bost. Journ. Nat. Hist., p. 263, Photogr. Pl. 3, figs. 21–23.

1858. **Batocr. æqualis** Hall. (**Actinocr. æqualis**) Geol. Rep. Iowa, i, pt. ii, p. 592, Pl. 11, figs. 4 a, b; Meek and Worthen, 1873, **Batocr. æqualis**, Geol. Rep. Ill., v, p. 367. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. doris** Hall, 1861. Desc. New Sp. Crin., p. 15; Meek and Worthen, 1873, **Batocr. doris**, Geol. Rep. Ill., v, p. 367.

*1860. **Batocr. andrewsianus** McChesney. (**Actinocr. andrewsianus**) New Pal. Foss., p. 27; also 1867, Chicago Acad. Nat. Sci., p. 20, Pl. 5, fig. 5. Upper Burlington limest. Burlington, Iowa.

1858. **Batocr. biturbinatus** Hall. (**Actinocr. biturbinatus**) Geol. Rep. Iowa, i. pt. ii, p. 616, Pl. 16, figs. 5, 6, a, b, c; Meek and Worthen, Geol. Rep. Ill., v, p. 367. Keokuk limest. Illinois and Iowa.

1860. **Batocr. calyculus** Hall. (**Actinocr. calyculus**) Supp. Geol. Rep. Iowa, p. 55, Pl. 1, figs. 12 a, b, c; Meek and Worth., 1873, **Batocr. calyculus**, Geol. Rep. Ill., v, p. 367. Warsaw limest. Spurgeon Hills, Ind.

Syn. **Batocr. calyculus** var. **hardinensis** Meek and Worth., 1866. Proc. Acad. Nat. Sci. Phila., p. 253.

We doubt that the type specimen came from the St. Louis limest., it would be the only example of an Actinocrinoid being found beyond the Warsaw limest.

*1860. **Batocr. Caroli** Hall. (**Actinocr. Caroli**) Supp. Geol. Rep. Iowa, p. 54, Pl. 1, fig. 11. Warsaw limest. Warsaw, Ill.

1869. **Batocr. Cassedayanus** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 353; Geol. Rep. Ill., v, p. 370, Pl. 5, fig. 1. Lower Burlington limest. Burlington, Iowa.

1855. **Batocr. Christyi** Shum. (not Hall, 1863 = *Periechocr. Christyi.*) Figured in Christy's letters on Geol., Pl. 1, figs. 1, 2; Shumard, **Actinocr. Christyi,** Geol. Rep. Missouri by Swallow, pt. ii, p. 191, Pl. A, fig. 3; Meek and Worth., 1873, **Batocr. Christyi,** Geol. Rep. Ill., v, p. 367, Pl. v, figs. 4 a, b; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 231. Upper Burlington limest. Burlington, Iowa.

1860. **Batocr. clypeatus** Hall. (**Actinocr. clypeatus**) Supp. Geol. Rep. Iowa, p. 12, Pl. 3, fig. 12; Meek and Worth., 1867, **Batocr. clypeatus,** Geol. Rep. Ill., ii, p. 150. Lower Burlington limest. Burlington, Iowa

Syn. **Actinocr. inornatus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 24; Meek and Worth., **Batocr. inornatus,** Geol. Rep. Ill., v, p. 367.

Syn **Actinocr. papillatus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 29, Pl. 3, figs. 10, 11; Meek and Worth., **Batocr. papillatus,** Geol. Rep. Ill., v, p. 367.

1858. **Batocr. discoideus** Hall. (**Actinocr. discoideus**) Geol. Rep. Iowa, i, pt. ii, p. 594; Meek and Worth., 1867, **Actinocr.** (**Batocr.**) **discoideus,** Geol. Rep. Ill., ii, p. 150, and 1873, **Batocr. discoideus,** Ibid., v, p. 367. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. formosus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 30; Meek and Worth., 1873, **Batocr. formosus,** Geol. Rep. Ill., v, p. 367.

Syn. **Actinocr. subæqualis** McChesney, 1860. Desc. Pal. Foss., p. 17; also 1867, Chicago Acad. Nat. Sci., p. 13, Pl. 5, fig. 7; Meek and Worth., **Batocr. subæqualis,** Geol. Rep. Ill., v, p. 367.

1861. **Batocr. dodecadactylus** Meek and Worth. (**Actinocr. dodecadactylus**) Proc. Acad. Nat. Sci. Phila., p. 131, and 1866, **Batocr. dodecadactylus,** Geol. Rep. Ill., ii, p. 205, Pl. 15, figs. 3 a, b, c, and Ibid., v, p. 368. Upper Burlington limest. Burlington, Iowa.

This species forms an exception to the rule in having apparently only twelve arms. It may possibly be a young **B. rotundus,** and that some of the arms branch off in the free state.

*1860. **Batocr. euconus** Meek and Worth. (**Actinocr.—Alloprosallocr.—euconus**) Proc. Acad. Nat. Sci. Phila., p. 164, changed in 1873 to **Batocrinus (Alloprosallocrinus euconus),** Geol. Rep. Ill., v, p. 368. Warsaw limest. Spurgeon Hills, Ind.

1860. **Batocr. Hageri** McChesney. (**Actinocr. Hageri**) New Pal. Foss., p. 28; also 1867, Chicago Acad. Nat. Sci., p. 21, Pl. 4, fig. 1; Meek and Worth, 1873, **Batocr. Hageri,** Geol. Rep. Ill., v, p. 367. Upper Burlington limest. Burlington, Iowa.

1854. **Batocr. icosidactylus** Casseday. (Type of the genus.) Deutsche Geol. Gesellschaft, vi, p. 238; Meek and Worth., 1867, **Actinocr.** (**Batocr.**) **icosidactylus,** Geol. Rep. Ill., v, 367. Warsaw limest. Spurgeon Hills, Ind.

*1859. **Batocr. Indianænsis** Lyon and Cass. (**Actinocr. Indianænsis**) Am. Journ. Sci. and Arts, vol. 29, p. 75; Meek and Worth., 1873, **Actinocr. Indianænsis,** Geol. Rep. Ill., v, p. 341. Keokuk limest. Crawfordsville, Ind.

1854. **Batocr. irregularis** Casseday. Deutsche Geol. Gesellschaft, vi, p. 238; Meek and Worthen, 1867, Geol. Rep. Ill., ii, p. 150; also 1873. Ibid., v, p. 367. Warsaw limest. Spurgeon Hills, Ind.

1860. **Batocr. lagunculus** Hall. (**Actinocr. lagunculus**) Supp. Geol. Rep. Iowa, p. 41; Meek and Worth., **Batocr. lagunculus,** Geol. Rep. Ill., v, 367. Keokuk limest. Iowa and Illinois.

*1861. **Batocr. laura** Hall (**Actinocr. laura**). Descr. New Sp. Crin., p. 15. Upper Burlington limest. Burlington, Iowa.

1860. **Batocr. lepidus** Hall (**Actinocr. lepidus**). Supp. Geol. Rep. Iowa, p. 32; Meek and Worth. **Batocr. lepidus,** Geol. Rep. Ill., v, p. 367. Lower Burlington limest. Burlington, Iowa.

1858. (?). **Batocr. longirostris** Hall. (**Actinocr. longirostris**) Geol. Rep. Iowa, i, pt. ii, p. 589, Pl, 11, figs. 2, 4 c, d; Meek and Worth., **Batocr. longirostris,** Geol. Rep. Ill., v, p. 367. Lower Burl. limest. Burlington, Iowa. This species shows a marked departure from the characters of the genus and its reference is not without doubt.

1860. **Batocr. mundulus** Hall. (**Actinocr mundulus**) Supp. Geol. Rep. Iowa, p. 39; Meek and Worth., **Batocr. mundulus,** Geol. Rep. Ill., v, p. 367. Keokuk limest. Keokuk, Iowa.

1850. **Batocr. Nashvillæ** Troost. (**Actinocr. Nashvillæ**) Cat. Crin. Tenn. (Proc. Am. Assoc. for Advanc. of Sci., p. 60); Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 609, Pl. 15, fig. 4, and Pl. 16, figs. 4 a, b; Wachsm. and Spr. 1878, Proc. Acad. Nat. Sci. Phila., p. 234; Meek and Worth., **Batocr. Nashvillæ,** Geol. Rep. Ill., v, p. 368. Keokuk limest. Iowa, Illinois, Missouri, Tennessee and Kentucky.

Var. **subtractus** White. (**Actinocr. Nashvillæ** var. **subtractus**), Proc. Bost. Soc. Nat. Hist., ix, p. 16. Upper Burlington limest. and Keokuk Transition beds.

1865. **Batocr. pistilliformis** Meek and Worth. (**Batocr.—Uperocr.—pistilliformis**), Proc. Acad. Nat. Sci. Phila., p. 153; also 1866, **Actinocr.** (**Batocr. C. Uperocr**) **pistilliformis,** Geol. Rep. Ill., ii, p. 151, Pl. 14, fig. 8; Ibid., 1873, v, p. 367. The original is said to be obtained from the Kinderhook gr. of Marion Co., Ill., but more probably from the Burlington limest., and that it is a *Syn.* of **B. pyriformis.**

Syn. **Actinocr. pyriformis** var. **rudis** Meek and Worth. Proc. Acad. Nat. Sci. Phila. (not **A. rudis** Hall, 1860).

1865. **Batocr. pistillus** Meek and Worth. (**Actinocr.—Uperocr.—pistillus**) Proc. Acad. Nat. Sci. Phila., p. 152; also 1868, **Actinocr.—Batocr.—pistillus.** Geol. Rep. Ill., iii, p. 472, Pl. 16, figs. 4 a, b; 1873, **Batocr. pistillus.** Ibid., v, p. 367. Upper Burl. limest. Burlington, Iowa.

1860. **Batocr. planodiscus** Hall. (**Actinocr. planodiscus**) Supp. Geol. Rep. Iowa, p. 45; Meek and Worth., 1873, **Batocr. planodiscus,** Geol. Rep. Ill., v, p. 367; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 233. Keokuk and Burlington Transition bed and Lower Keokuk limest. Nauvoo, Ill., and Keokuk rapids.

1855. **Batocr. pyriformis** Shumard (**Actinocr. pyriformis,** not Ad. Roemer, 1856). Geol. Rep. Missouri by Swallow, pt. ii, p. 192, Pl A, figs. 6 a, b; Meek and Worth., 1865, **Actinocr.—Uperocr.—pyriformis.** Proc. Acad. Nat. Sci. Phila., p. 153; also 1873 (**Batocr. pyriformis**). Geol. Rep. Ill., v, p. 375, Pl. 5, fig. 5, and Ibid., ii, p. 150; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 233. Upper Burlington limest. Burlington, Iowa, and Illinois and Missouri.

1869. **Batocr. quasillus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 352; also Geol. Rep. Ill., v, p. 369 Pl. 5, fig. 2. Lower Burlington limest. Burlington, Iowa.

1855. **Batocr. rotundus** Yandell and Shum. (Figured in Christy's letters on Geology, 1848, as *Actinocrinites*). Yand. and Shum., Geol. Rep. Missouri by Swallow, pt. ii, p. 191, Pl. A, figs. 2 a, b; Meek and Worth., 1873, **Batocr. rotundus.** Geol. Rep. Ill., v, p. 367. The leading fossil of the Upper Burlington limest. Boone and Marion Cos., Mo., Quincy and Oquaka, Ill., Burlington, Iowa. This is a somewhat variable species; it sometimes has a good sized anal tube, while in other cases this seems to be modified into a simple vault opening; the number of arms varies from eighteen to twenty-two.

Syn. **Actinocr. oblatus** Hall. Supp. Geol. Rep. Iowa, p. 38. (This species differs only in having twenty-two arms).

1860. **Batocr. similis** Hall. (**Actinocr. similis**) Supp. Geol. Rep. Iowa, p. 40; Meek and Worth , 1873, **Batocr. similis,** Geol. Rep. Ill., v, p. 367. Keokuk limest. Iowa and Illinois.

Syn. **Actinocr. clavigerus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 44; Meek and Worth., 1867, **Batocr. clavigerus,** Geol. Rep. Ill., v, p. 367.

1860. **Batocr. sinuosus** Hall. (**Actinocr. sinuosus**) Supp. Geol. Rep. Iowa, p. 27, Photogr. Pl. 3, figs. 8, 9; Meek and Worth., 1873, **Batocr. sinuosus.** Geol. Rep. Ill., v, p. 368. Upper Burlington limest. Burlington, Iowa.

*1860. **Batocr. steropes** Hall. (**Actinocr. steropes**) Supp. Geol. Rep. Iowa, p. 43. Keokuk limest. Keokuk, Iowa.

1869. **Batocr. trochiscus** Meek and Worth. Proc. Acad. Nat. Sci. Philad., p. 354; Geol. Rep. Ill., v, p. 372, Pl. 5, fig. 6. Burlington and Keokuk Transition Bed. Iowa and Ill. (A more mature stage of **B. Christyi**).

1858. **Batocr turbinatus** Hall. (**Actinocr. turbinatus**) Geol. Rep. Iowa, i, pt. ii, p. 587, Pl. 11, fig. 1; Meek and Worth., 1873, **Batocr. turbinatus,** Geol. Rep. Ill., v, p. 367. Lower Burlington limest. Burlington, Iowa. *Syn.* **Batocr. turbinatus,** var. **elegans** Hall. Geol. Rep. Iowa, i, pt. ii, p. 588, Pl. 11, fig. 5.

*1857. **Batocr. Yandelli** Shumard. (**Actinocr. Yandelli**) Trans. St. Louis, Acad. i, p. 9, Pl. 1, figs. 4 a, b; Meek and Worth. (**Actinocr.** Sect. A.), Geol. Rep. Ill., v, p. 341. Keokuk limest. Bottom mould Knob, Jefferson Co., Ky.

*1880. **Batocr. Wachsmuthi** White. (**Actinocr. Wachsmuthi,** not **A. Wachsmuthi,** 1862 = **Actinocr. scitulus**). Author's Edit. from the 12th Annual Rep. of U. S. Geol. Surv. by Hayden, p. 162, Pl. 40, figs. 1 a, b; Geol. Rep. Ind. for 1879-80, p. 142, Pl. 7, fig. 6. Keokuk limest. Crawfordsville, Ind.

We add the following new species:—

Batocrinus Lovei, Wachsm. and Spr.

Form of body wheel-shaped, as wide as high, running nearly to a point at each pole. Plates of the calyx smooth, without ornamentation, those of the dome convex. Basals forming a conical cup, slightly truncate below. Radials 3 × 5; the first larger than both the others combined; second twice as wide as high; the third with obtuse upper angles. There are two rows of two plates in the two succeeding orders, those of the third order larger than those of the second, and the outer plates wider than the inner ones. Each ray has four arm openings—except the anterior which has but two—the outer ones of the ray, and those between the main divisions are placed a little farther apart, but are not separated by any sinus. Each opening gives off a single arm, which is short, and from the base up composed of two series of plates. Near each arm opening, there is a conspicuous respiratory (?) pore, which like the arm opening is directed laterally.

Interradials two to three, the first large; anals one, three and three. Vault lower by one-third to one-half than the calyx; apical dome plates somewhat prominent; interradial spaces a little depressed. Ventral tube perfectly central, extending far beyond the tips of the arms. Column comparatively slender.

This species agrees in every particular with *B. Christyi*, except it generally is smaller, and it has a single arm in place of two from each arm opening. It also differs in the more depressed form of the vault, and in being found only at the base of the Upper Burlington limestone; while *B. Christyi* struggles through to the Burlington and Keokuk Transition beds.

Locality and Position.—Base of Upper Burlington limest. Subcarb. Burlington, Iowa.

This species is named in honor of Mr. James Love of Burlington, an excellent collector, and an ardent lover of Crinoids.

***Batocrinus Whitei** Wachsm. and Spr., n. sp.

Body small, globose, a little wider than high, height of calyx and dome equal, both with convex sides; the arm bases slightly projecting. Surface of plates ornamented, the median line of all radials up to the arm bases marked by a ridge; other less distinct elevations diverge from the centre of the first interradial plates, which continue to the radials, but without uniting with the radial ridges.

Base short, truncate, forming an elevated ring around the column. First primary radial almost as large as second and third together and considerably wider, the upper sloping sides comparatively long; the second fully as high as the third and nearly as wide.

Secondary radials 2 × 10, the upper largest, with two shorter pieces in the next order, making four arm openings in four of the rays, the anterior ray has no tertiary radials and only two openings in all. Each arm opening supports a single arm, which, from the second plate up, is constructed of two series of pieces alternately arranged. Arms nearly round, of medium thickness and length, gradually tapering to their tips. Pinnules very long, composed of joints three times longer than wide, and perfectly smooth. Interradials two to three, the first much larger than all others combined, and fully as large as the first radials. Anal area composed of one, three and two pieces, with a depression between the arm bases. Vault constructed of tuberculous pieces of nearly equal size. Anal tube long, extended beyond the arms, constructed of convex plates, which are interspersed all the way up to the top, with strongly nodose or slightly spiniferous pieces. Column slender, composed of alternately larger and smaller joints, the larger ones with rounded edges.

This species is interesting for its close affinities with *B. Indianænsis* from Crawfordsville, with which it agrees in all points except that *B. Whitei* is smaller by one-half, and has a single arm proceeding from each arm opening; while *B. Indianænsis* has always two as in the case of *B. Lovei* and *B. Christyi*.

We take pleasure in naming this species in honor of Dr. C. A. White of the National Museum, to whom we are indebted for many favors.

Geological Position, etc.—This species occurs in considerable quantities at Bono, Ind., but is rare at Canton and Edwardsville, Ind.; it is found in shaly layers, probably equivalent to the lower part of the Keokuk group.

23. ERETMOCRINUS Lyon and Casseday.

1859. Lyon and Cass. Am. Journ. Sci. and Arts (ser. 2), vol. 28, p. 241.
1866. Shumard. (Subgen. (?) of *Actinocr.*) Cat. Pal. Foss., pt. i, p. 369.
1869. Meek and Worthen. (Subgen. of *Batocr.*) Proc. Acad. Nat. Sci. Phila., p. 350.
1873. Meek and Worth. (Subgen. of *Batocr.*) Geol. Rep. Ill., v, p. 368.
1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 235.
1879. Zittel. (Subgen. of *Actinocr.*) Handb. d. Palæont., p. 370.
Syn. *Actinocrinus* (in part), Hall, 1861. Bost. Journ. Nat. Hist.

Lyon and Casseday's description of this genus was not very satisfactory and partly incorrect, and that is evidently the reason why it has never been recognized as it should be. Hall ignored it altogether, Shumard could not distinguish it from *Actinocrinus*, and Meek and Worthen, who adopted the name, placed it subgenerically at first under *Actinocrinus*, and later under *Batocrinus*. It differs from the former in almost the same characters as *Batocrinus*, but as distinctly from the latter, in the number and arrangement of the arms, in their greater length, depressed spatulate form; also in the form of the calyx, the extended basal ring, the preponderance of the dome portions over the calyx, the excentric position of the anal tube, its inflated character, and its disposition to bend sideways. We consider these characters sufficient for a full generic division, and propose the following:—

Revised Generic Diagnosis.—Body small, biturbinate or subglobose; calyx truncate at the base, composed of smooth, convex or nodose plates with rarely striations. Vault more or less inflated, and exceeding the calyx in its dimensions.

Basals three, equal, formed into a wide rim, which extends far beyond the periphery of the column. Primary radials 3 × 5; the first large, equal in size to the second and third together, and wider than either of them; the second quadrangular; the third regularly pentagonal, sometimes smaller than the second. Secondary radials composed of two series of plates each, and so are the tertiary radials when present. The plates of the marginal row, those supporting the arms, form a projecting circlet around the body, and are laterally extended; they are large, their outer sides excavated for the reception of the arm plates, the upper side notched for the ambulacral passages. At the side of the arm openings, which are generally directed obliquely toward the vault and close to the arm, there is located a respiratory (?) pore, which is arranged like in *Batocrinus*, and generally as large. The arm openings are arranged in groups of two, three, four, or five each, with great variability in the different rays. There are from twelve to twenty-two arm openings in all, and each one supports either a simple or a compound arm. The openings of adjacent rays are placed farther apart than those of the same ray, and are separated by a small depression, which at the posterior side of the body is considerably deeper and wider.

Arms fully twice as long as in *Batocrinus*, the upper portions flattened, much wider, and folded inward. They are composed of a double series of joints, which at the bottom rest upon one or two small cuneate pieces. The succeeding arm plates are generally short, but they become gradually longer as they increase in width. The lower portions of the arms are round or nearly so, the increase in width beginning at one-fourth to one-third their height, when they are gradually flattened, spread out laterally, and become broad and spatulate, remaining thick and heavy along the middle line, growing thin toward the edges. In some species the arms become fully an inch wide, while in others the increase in width is comparatively insignificant. In some species, every arm joint from both sides is extended, in others only every second, third or fourth joint, while the intermediate ones remain narrow. In these arms the wider joints appear in the form of lateral spines, which begin short, but gradually increase to a considerable length. Ambulacral furrows deep; pinnules similar to those of *Batocrinus.*

Interradial plates one to three, the first large, extended to the middle portions of the third primary radials, the upper ones very small. Anals, one in the first, three in the second series, with a few additional plates above. Interaxillaries none.

Dome elevated, inflated, generally larger than the calyx, composed of nodose or spiniferous plates; the apical plates more prominent and larger; the large centre piece occupying the very centre of the vault; posterior side with a shallow depression filled by small anal pieces.

Anal tube strong, more or less excentric, extending beyond the infolding arms, and frequently bent abruptly to one side; the middle portions more or less inflated, top and base of almost equal width, the upper end provided with a small opening.

Column round, composed of very wide pieces alternating with much smaller ones, the former frequently with sharp edges; central canal small.

Geological Position, etc.—Eretmocrinus occurs at the age of the Burlington and Keokuk groups, in America only.

We recognize the following species:—

1861. **Eretmocrinus attenuatus** Hall. (**Actinocr. matuta** var. **attenuata**) Desc. New. Sp. Crin. p, 14. Upper Burlington limest. Burlington, Iowa.

1860. **Eretmocr. calyculoides** Hall. (**Actinocr. calyculoides**) Supp. Geol. Iowa, p. 17, Photogr. Pl. 3, figs. 2–5; Meek and Worth., 1873, **Batocr.** (**Eretmocr.**) **calyculoides** Geol. Rep. Ill., v, p. 368. Upper Burl. limest. Burlington, Iowa.

1861. **Eretmocr. carica** Hall. (**Actinocr. carica**) Desc. New. Sp. Crin. p. 10; Meek and Worth, 1873, **Batocr.** (**Eretmocr.**) **carica,** Geol. Rep. Ill., v, p. 368. Lower Burlington limest. Burlington, Iowa.

1861. **Eretmocr. clio** Hall. (**Actinocr. clio**) Desc. New. Sp. Crin. p. 1; also Bost. Journ. Nat. Hist., p. 262, Photogr. Pl. 3, fig. 7; Meek and Worth., 1873, **Batocr.** (**Eretmocr.**) **clio,** Geol. Rep. Ill., v, p. 368. Lower Burlington limest. Burlington, Iowa.

1861. **Eretmocr. clœlia** Hall. (**Actinocr. clœlia**) Desc. New. Sp. Crin., p. 1; also Bost. Journ. Nat. Hist., p. 266; Meek and Worth., 1873, **Eretmocr. (Batocr.) clœlia,** Geol. Rep. Ill., v, p. 368. Upper Burlington limest. Burlington, Iowa.

1861. **Eretmocr. corbulis.** (**Actinocr. corbulis**) Desc. New. Sp. Pal. Crin. p. 1; also Bost. Journ. Nat. Hist., p. 265; Meek and Worth., **Batocr.—Eretmocr.**(?)—**corbulis,** Geol. Rep. Ill., v, p. 368. Lower Burlington limest. Burlington, Iowa.

*1860 **Eretmocr. coronatus** Hall. (**Actinocr. coronatus**) Supp. Geol. Rep. Iowa, p. 28, Photogr. Pl. 3, figs. 1–2. Lower Burlington limest. Burlington, Iowa.

1860. **Eretmocr. gemmiformis** Hall. (**Actinocr. gemmiformis**) Supp. Geol. Rep. Iowa, p. 23, Photogr. Pl. 3, fig. 6; Meek and Worth., **Batocr.—Eretmocr.**(?)—**gemmiformis,** Geol. Rep. Ill., v, p. 368. Lower Burlington limest. Burlington, Iowa.

*1855. **Eretmocr. Konincki** Shumard. (**Actinocr. Konincki**) Geol. Rep. Missouri; by Swallow, pt. ii, p. 194, Pl. A, figs. 8 a, b, c; Meek and Worth., **Batocr. Konincki,** Geol. Rep. Ill., v, p. 367. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. urnæformis** McChesney, 1860. New. Pal. Foss. p. 23; Meek and Worth., **Batocr.—Eretmocr.**(?)—**urnæformis,** Geol. Rep. Ill., v, p. 368.

*1861. **Eretmocr. leucosia** Hall. (**Actinocr. leucosia**) Desc. New. Pal. Crin., p. 1; also Bost. Journ. Nat. Hist., p. 261. Lower Burlington limest. Burlington, Iowa.

1859. **Eretmocr. magnificus** Lyon and Cass. Type of the genus. Am. Journ. Arts and Sci. (ser. 2), vol. 28, Septbr., p. 241; Meek and Worth., **Batocr.—Eretmocr.—magnificus,** Geol. Rep. Ill., v, p. 368. Keokuk limest. Hardin Co., Ky.

1861. **Eretmocr. matuta** Hall. (**Actinocr. matuta**) Desc. New. Sp. Crin., p. 14; Meek and Worth., Geol. Rep. Ill., v, p. 368. Upper Burlington limest. Burlington, Iowa.

1869. **Eretmocr. neglectus** Meek and Worth. (**Batocr.—Eretmocr.—neglectus**) Proc. Acad. Nat. Sci., Phila., p. 355; Geol. Rep. Ill., v, p. 377, Pl. 5, fig. 3. Lower Burlington limest. Burlington, Iowa.

1858. **Eretmocr. ramulosus** Hall. (**Actinocr. ramulosus**) Geol. Rep. Iowa, i, pt. ii, p. 615, Pl. 15, fig. 7; Wachsm. and Spr., 1878. Proc. Acad. Nat. Sci., Phila., p. 237. Burlington and Keokuk Transition bed, and Lower Keokuk limest. Burlington and Augusta, Iowa, and Nauvoo, Ill.

It is more than probable that this species is a *Syn.* of **E. magnificus.**

1861. **Eretmocr. remibrachiatus** Hall. (**Actinocr. remibrachiatus**) Desc. New. Sp. Crin., p. 11, Photogr. Pl. 3, fig. 8–9; Meek and Worth., Geol. Rep. Ill., v, p. 368. Upper Burlington limest. Burlington, Iowa.

1855. **Eretmocr. Verneuilianus** Shumard. (**Actinocr. Verneuilianus**) Geol. Rep. Missouri, by Swallow, Pt. ii, p. 193, Pl. A, figs. 1a, b; Meek and Worth. **Batocr.—Eretmocr.—Verneuilianus** Geol. Rep. Ill., v, p. 368, Pl. 4, figs. 3 and 4. Upper Burlington limest. Burlington, Iowa, Illinois and Missouri.

Next to **Batocr. rotundus** this is the most characteristic species of the Burlington group. It does not represent a typical form of this genus, the arms like those of **E. Konincki** being but little flattened, but its structure otherwise leaves no doubt that it belongs to **Eretmocrinus.**

We further place here the following new species, which are interesting as all three are of a similar type, and either descendants from each other, or closely related to each other:—

Eretmocrinus originarius n. sp.

Body small, calyx and dome of equal height, the former subturbinate with nearly straight sides, the vault somewhat inflated, with convex sides. Radial plates covered with an obscure ridge, passing longitudinally from plate to plate, all other plates of the calyx nearly or quite smooth.

Basal cup low, truncate at the bottom, extending into a ring which projects beyond the rather large column. First radial as large as second and third combined; the second much shorter, quadrangular, twice as wide as high; the third as large as the second, and but little wider, the lateral sides almost straight. Secondary radials consisting of two series of plates, which are of a similar form as the two upper primary radials but smaller. They are followed in the anterior ray by the arms, in the four other rays by tertiary radials. In the lateral rays both upper and secondary radials are axillary, and give off 2 × 2 tertiary radials with four arm openings, the two postero-lateral rays have three, of which one side only is bifurcating, while the other remains simple. Arms simple throughout, of medium length, the tips slightly spatulate and folded inward; composed of rather high, somewhat convex joints, with comparatively strong pinnules.

Interradials three, the first very large, with a faint node in the centre; anals one, three and two. Dome composed of convex plates ; annal tube unknown, but evidently not very large.

Geological Position, etc.—From the age of the earlier Keokuk limest., near Bono, Lawrence Co., Ind., where the species occurs in great quantities. Collection of Chas. Wachsmuth.

Eretmocrinus intermedius n. sp.

In form, size, and ornamentation resembling *E. originarius*, perhaps a little more truncate at the basal portions, and the arm bases more spreading, differing, however, in the arm structure. It has normally six arms from each posterior, and four from the rest of the rays, twenty-four arms to the individual. The radial portions of the calyx, in the lateral rays, are unchanged, while the anterior ray has in addition 2 × 2 tertiary radials, and consequently twice the number of arms. In the posterior rays, both second tertiary radials are bifurcating, and give to the inner side of the ray a simple arm, to the outer 2 × 2 quaternary radials, of which each series supports an arm. The plates of the upper order of radials, all around the body, and frequently the last axillary plate of the posterior rays, are not enclosed within the body or only partly so, thus remaining in a somewhat undeveloped state, while they are in form and size regular radials. Compared with *B. originarius*, the arms are more crowded, the upper portions more spatulate. Arm joints transversely angular, the outer sides straight or very little convex. Vault unknown.

Geological Position, etc.—From the same layer as the preceding species, and almost as common. Collection of Chas. Wachsmuth.

Eretmocrinus adultus n. sp.

Plates apparently without ornamentation. Calyx low basin-shaped, with a projecting rim along the basals. First radials a little shorter than second and third together, but wider than either of them ; the third wider than the second. The higher orders of radials comparatively large, composed of two plates each, which increase in size upward, those forming the arm bases very much wider, as large or larger than the first primary radials. Articulating scar or facet for the attachment of the arms occupying but little more than one-half to two-thirds the width of the plates, somewhat projecting, thereby producing a shallow depression between the arm bases, outer face truncate or concave. The concavity is filled by three arm pieces, a central one which is angular above, and a shorter piece on each side of it, the latter of the height of the regular arm joints but narrower. They are followed by a similar piece on each side, and two other pieces resting against the sloping sides of the little axillary plate, alternating with the former, and constituting the base of two arms, which from the second or third joint become free. The species has fourteen pairs of arms, two in the anterior ray, and three in each of the others. Arms long gradually flattening at midway, upper portions strongly spatulate and folded inward.

Interradials consisting of one large plate, succeeded either by one or two smaller ones, or by a single large, elongate piece, wedged in between the plates of the higher order of radials. Anals one, three, and three plates. Vault unknown ; anal tube long, extending considerably beyond the arms, of rather large size, composed of smooth plates. *E. adultus* agrees in its double arm structure with *Batocr. Indianænsis* and *B. Christyi*, but has spatulate arms and a very different arm formula. It is of the type of *Eretmocr. originarius* with which it is more closely allied than would appear at first sight. *E. adultus* is larger and especially broader, but this is evidently due to the double arm structure which required those modifications, the differences are similar to those between *Batocr. Lovei* and *B. trochiscus.*

Geological Position, etc.—Keokuk limest. Canton, and Edwardsville, Ind. Collection of Chas. Wachsmuth.

24. DORYCRINUS Roemer.

1854. F. Roemer. Archiv f. Naturgesch., Jahrg., xix, Band i, p. 207.
1855. F. Roemer. Lethæa Geogn. (Ausg. 3), p. 249.
1869. Meek and Worth. Proc. Acad. Nat. Sci., Phila., p. 165.
1873. Meek and Worth. Geol. Rep. Ill., v, p. 379.
1879. Zittel. (Subgenus of *Amphoracrinus*). Handb. d. Palæont., i, p. 370.
Syn. *Amphoracrinus* Meek and Worth. (not Austin), 1866, Geol. Rep. Ill., ii, p. 209.
Syn. *Actinocrinus* (*Amphoracr.*) Meek and Worth., 1861, Proc. Acad. Nat. Sci., Phila., p. 132.
Syn. *Sphærocrinus* Meek and Worth., 1865 (not Roemer, 1851). Ibid., p. 154.
Syn. *Cœlocrinus* Meek and Worth., 1865 (not *Cœliocrinus* White, 1863). Ibid., p. 273; and 1868, Geol. Rep. Ill., ii, p. 215.

Roemer's typical species of *Dorycrinus* is provided with six large spines at the vault, and upon this peculiarity, principally, the genus was founded. In regard to this point the genus must be amended, as there are other species, evidently belonging to the same group, which have only a central spine, others have three, and still others in place of the spines a large convex or nodose plate. There are, however, other excellent distinctions which make *Dorycrinus* a good genus.

Neither Hall, Shumard, de Koninck and Lehon, Pictét, nor Schultze, have recognized *Dorycrinus*, all referring the species to *Actinocrinus*, with which it agrees only in the general family characters, and in having the rays extended into lobes. *Dorycrinus* inclines far more toward *Batocrinus* and *Eretmocrinus*, with which it agrees in the general form of its plates, and in the peculiar double arm structure, which became here a constant character. It differs, however, very essentially in the lobed form of the body, its strongly expressed bilateral symmetry, in the lateral position of the anus, and in its opening out directly through the body, as also the shortness and delicacy of the arms. It differs from *Agaricocrinus* and *Amphoracrinus* in the form and proportions of the body, in the arrangement of the plates, and in the altogether different arm structure.

We place Meek and Worthen's subgenus *Cœlocrinus*, which had been previously described, successively, under *Actinocrinus*, *Amphoracrinus* and *Sphærocrinus*, as a synonym under *Dorycrinus*, the only known species being a somewhat aberrant form, but not sufficiently distinct even to make it a subdivision.

Generic Diagnosis.—Calyx broadly turbinate or subglobose, truncate at the base, and deeply sinuate at the interradial spaces, the sinus at the posterior side much deeper and wider, and extending up to the vault, thereby giving to the body a decidedly pentalobate aspect, with a strongly expressed bilateral symmetry. Dome from one-fourth to one-half the height of the body, strongly convex, composed of comparatively few and large plates, frequently armed with one to six spines. Plates sometimes corrugated, but not striated, and all more or less convex or nodose.

Basals three, equal, short, in the typical forms of the genus abruptly spreading, the lower exterior margins extending almost at right angles to the axis of the fossil; deeply sinuate at the sutures, but sometimes forming a continuous ring. Primary radials 3 × 5; the first as large or larger than the second and third together; the second much narrower than the first, but wider than high, quadrangular in outline, although sometimes (in the same specimen) pentagonal or hexagonal, owing to the position of the second series of interradials, upper and lower sides parallel; the third more or less pentagonal, wider than high, wider in rays with three or four arm bases than with two. The third radial, in rays with only two arm openings, with 2 × 2 secondary radials, which support the arms, but in rays with three or four openings, and consequently with tertiary radials, the secondary radials consist of a single series of plates, of which one or both are axillary. In the latter case, the plate gives off 1 × 2 arm-bearing plates, in the former another row of secondary radials, which support the arms. The arm bearing plates, all around the body, are projecting, rounded toward their sides, and separated by a deep lateral depression or sinus, which is deeper and wider between the main divisions of the ray, and which at the space between the rays forms a wide and deep gap. *Dorycrinus* has variously from twelve to twenty arm openings to the species, and twice that number of arms, two to each opening, given off in a similar manner as in some species of *Batocrinus* and *Eretmocrinus*. The arm openings are unequally divided among the rays, only species with twenty openings having four to each ray. In species with a less number, the posterior rays are stronger, and have always four openings, except when there are only twelve openings in all. The anterior ray is generally stronger, or has at least as many arms as the antero-lateral rays, which, as a rule, are the least developed, and in most species have but two pairs of arms. Slight variations in the arm formula of the same species occur frequently in this genus. Respiratory (?) pores close to the arm openings.

Interradials two or three, rarely more, in two series; the first very large, frequently but not always extending to the third primary radials; the plates of the upper series small, placed within the sinus between the rays, and hence are connecting with the interradial dome plates. Anal area constructed very differently from the interradial, composed of a large plate in line with the first radials, but higher than those, with the upper sloping sides longer. There are three plates in the second series, the middle one larger with truncate upper side, succeeded by a row of two to four similar plates, which form a longitudinal line, often elevated into a ridge up to the anal aperture. The opening is surrounded by one or two rows of plates, which at the upper side lean against the central dome piece It is a simple aperture penetrating a somewhat thickened protuberance, and nearly always situated and directed laterally. No interaxillary plates.

Dome elevated, inflated, occasionally a little depressed toward the middle. Plates large, centre plate and the first five radial pieces larger than the proximal dome pieces, and frequently extended into spines, which in some extreme cases attain a length of three to four inches. There are other species with only a central spine, and still others in which the respective plates are only larger or more convex. The proximal plates connect with the centre piece, they are very regularly arranged and readily recognized, but otherwise not distinct from the rest of the vault pieces.

Column round, not strong, and composed alternately of much larger and smaller segments; central canal small.

Geological Position, etc.—Dorycrinus is in America a strictly

Lower Subcarboniferous genus; the only species so far recognized in Europe has been found in the Devonian of the Eifel.

The following is a list of the known species:—

1869. **Dorycrinus canaliculatus** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 166; Geol. Rep. Ill., v, p. 381, Pl. 6, fig. 4. Lower Burlington limest. Burlington, Iowa.

*1861. **Dorycr. concavus** Meek and Worth. (**Actinocr. concavus**) Proc. Acad. Nat. Sci. Phila., p. 131; **Sphærocr. concavus** Meek and Worth., 1865, Ibid., p. 154; **Cœlocr. concavus** Meek and Worth., 1865 (Dec.), Ibid., p. 273; also Geol. Rep. Ill., ii, p. 215, Pl. 15, figs. 10 a, b, c. Lower Burlington limest. Burlington, Iowa.

1858. **Dorycr. cornigerus** Hall. (**Actinocr. cornigerus,** not **A. cornigerus** Lyon and Casseday) Geol. Rep. Iowa, i, pt. ii, p. 576, Pl. 9, figs. 12 a, b, c; also Ibid., Supp., Pl. 3, fig. 4; Meek and Worth., **Dorycr. cornigerus,** Geol. Rep. Ill., p. 380. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. divaricatus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 11.

Syn. **Actinocr. quinquelobus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 15; Meek and Worth. **Dorycr. quinquelobus** 1873. Geol. Rep. Ill., v, p. 380.

*1860. **Dorycr. decornis** Hall. (**Actinocr. decornis**) Supp. Geol. Rep. Iowa., p. 13. Burlington limest. Burlington, Iowa.

(This is a very doubtful species.)

1858. **Dorycr. Gouldi** Hall. (**Actinocr. Gouldi**) Geol. Rep. Iowa., i, pt. ii, p. 613, Pl. 15, figs. 6 a, b; Meek and Worth. *Dorycr. Gouldi,* Geol. Rep. Ill., v, p. 380. Lower part of the Keokuk limest. Keokuk, Iowa.

1875. **Dorycr. Kelloggi** Worthen, Geol. Rep. Ill., vi, p. 513, Pl. 29, fig. 8. Keokuk limest. Keokuk, Iowa.

1853. **Dorycr. mississippiensis** Roemer. Type of the genus. Archiv f. Naturgesch., Jahrg. xix, Band i, Pl. 10, figs. 1, 2, 3; Meek and Worth., 1873, Geol. Rep. Ill., v, p. 380. Keokuk limest. Iowa, Illinois, Tennessee, Kentucky and Missouri.

Syn. **Actinocr. (Dorycr). mississippiensis** var. **spiniger** Hall, 1860. Supp. Geol. Rep. Iowa., p. 54. (This is merely a young form.)

1858. **Dorycr. missouriensis** Shumard. (**Actinocr. missouriensis**) Geol. Rep. Missouri, by Swallow, pt. ii. p. 190, Pl. A, figs. 4 a, b, c; Meek and Worth. **Dorycr. missouriensis,** 1873. Geol. Rep. Ill., v, p. 380. Upper Burl. limest. Palmyra, Mo. and Burlington, Iowa. (This species is very variable in the number of arms.)

Syn. **Actinocr. desideratus** Hall. Desc. New Sp. Crin. p, 2; Bost. Journ. Nat. Hist., p. 273; Meek and Worth. **Dorycr. desideratus,** Geol. Rep. Ill., v, p. 380.

*1855. **Dorycr. parvus** Shumard. (**Actinocr. parvus**) Geol. Rep. Mo., by Swallow, ii, p. 193, Pl. A, fig. 9; Upper Burlington limest. (not St. Louis limest. as quoted by Shumard), Palmyra, Mo. and Burlington, Iowa.

Syn. **Actinocr. trinodus** Hall, 1858. Geol. Rep. Iowa, i, pt. ii, p. 575.

Syn. **Actinocr. symmetricus** Hall, 1858. Geol. Rep., Iowa, i, pt. ii, p. 574, Pl, 9, figs. 8 a, b; Meek and Worth., **Dorycr. symmetricus** 1873, Geol. Rep. Ill., v, p. 380.

Syn. **Actincor. (Amphoracr.) subturbinatus** Meek and Worth., 1860, Proc. Acad. Nat. Sci. Phila., p. 388; Geol. Rep. Ill., ii, p. 212, Pl. 15, figs. 4 a, b. **Dorycr. subturbinatus,** 1873, Ibid., v, p. 380.

*1862 (?) **Dorycr. præcursor** Hall. (**Actinocr. præcursor**) 15th Rep. N. Y., St. Cab. Nat. Hist., p. 131. Hamilton gr. Western New York.

We refer this species with doubt to the genus; it is imperfectly known.

*1855. **Dorycr. prumiensis** Müller. (**Actinocr prumiensis**) Verhand. Naturhist. Verein. f. Rheinlande, xii, p. 81, Pl. 9, figs. 1, 5; also 1857. **Pyxidocr. prumiensis** Neue Echin. Eifl. Kalk, p. 253, Schultze, 1867, Mon. Echin. Eifl. Kalk, p. 60, Pl. 6, fig. 6. Devon. Eifel, Germ.

1868. **Dorycr. quinquelobus** (var.) **intermedius** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 346; Geol. Rep. Ill., v, p. 385, Pl. 10, fig. 4. Transition bed between Burl. and Keok. limest. Pleasant Grove, Iowa. This is more properly a variety of **D. mississippiensis**, from which it differs only in having fewer arms and in its smaller size.

1868. **Dorycr. Roemeri** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 346; also Geol. Rep. Ill., v, p. 383, Pl. 10, fig. 3. Uppermost part of Upper Burl. limest. Burlington, Iowa.

*1860. **Dorycr. spinosulus** Hall. (**Actinocr. spinosulus**) Supp. Geol. Rep. Iowa., p. 52, Keokuk limest. Nauvoo, Ill. (Probably a young **D. mississippiensis.**

*1858. **Dorycr. subaculeatus** Hall. (**Actinocr. subaculeatus**) Geol. Rep. Iowa, i, pt. ii, p. 570, Pl. 10. figs. 2 a-b; Meek and Worth., **Dorycr. subaculeatus**, Geol. Rep. Ill., v, p. 380. Lower Burlington limest. Burlington, Iowa.

1850. **Dorycr. unicornis** Owen and Shumard. (**Actinocr. unicornis**) Journ. Acad. Nat. Sci. Phila., ii. (ser. ii), p. 67; also U. S. Geol. Rep. Iowa, Wis. and Minn., p. 573, Pl. 5 a, figs. 12 a, b; Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 568, Pl. 10, figs, 5 a, b, c; Meek and Worth., 1873, **Dorycr. unicornis**, Geol. Rep Ill. v, p. 380, Pl. 6, fig. 2. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. tricornis** Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 569.

Syn. **Actinocr. pendens** Hall, 1860. Ibid., Supp., p. 31.

*1861. **Dorycr. unispinus** Hall. (**Actinocr. unispinus**) Desc. New Sp. Crin. p. 2; also Bost. Journ. Nat. Hist., p. 270. Lower Burlington limest. Burlington, Iowa.

C. RHODOCRINIDÆ Roemer.

(Amend. Zittel, amend. Wachsm. and Spr.)

The genera which we include among the *Rhodocrinidæ* were arranged by the earlier writers, either in connection with such genera as *Cyathocrinus*, *Poteriocrinus*, or in various ways with *Actinocrinus*, *Melocrinus*, *Dimerocrinus*, *Periechocrinus*, *Carpocrinus* and others.

Austin[1] placed *Rhodocrinus* and *Sagenocrinus* under the Actinocrinoidea, *Dimerocrinus* under the Merocrinoidea.

D'Orbigny[2] placed *Gilbertsocrinus* and *Dimerocrinus* under the Melocrinidæ, *Glyptocrinus* and *Rhodocrinus* under the Cyathocrinidæ.

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[1] Ann. and Mag. Nat. Hist., 1842-3.

[2] Course elém. de Paléont., 1852, vol. 2.

Pictét[1] arranged *Rhodocrinus*, *Acanthocrinus*, *Dimerocrinus*, and *Thysanocrinus* under the Cyathocriniens, *Lyriocrinus* and *Scyphocrinus* Hall (not Zenker), under the Carpocriniens, and all under the Cyathocrinidæ.

Roemer,[2] who was the first to propose the name Rhodocrinidæ, referred to it only the genus *Rhodocrinus*, placing *Sagenocrinus* with the Sagenocrinidæ, *Thysanocrinus* with the Poteriocrinidæ, and *Dimerocrinus* which we take to be identical with *Thysanocrinus* he referred to the Cyathocrinidæ.

The great dissimilarity which manifests itself in these classifications, must be partly attributed to the imperfect knowledge which prevailed with regard to some of those genera at that time. It was evidently the intention of the writers to group the Crinoids according to the presence or absence of underbasals, the number of basals and the arm structure, but these parts had been often incorrectly represented, or were as yet entirely unknown.

A very marked improvement is visible in the classification of Zittel[3] who placed among the Rhodocrinidæ, *Ollacrinus*, *Rhodocrinus*, *Acanthocrinus*, *Ripidocrinus*, and *Thysanocrinus*, and proposed the name Glyptocrinidæ for *Glyptocrinus*, *Glyptaster*, *Thylacocrinus*, *Lampterocrinus*, *Eucrinus*, and *Sagenocrinus*, these genera, without exception, have underbasals, and Zittel discriminated distinctly between genera in which the calyx is constructed exclusively of three rings of plates, and those in which the radials are separated by interradials—our Sphæroidocrinidæ—and he distinguished these from our Ichthyocrinidæ. He, however, placed *Dimerocrinus* with some of our Actinocrinidæ, as that genus was thought to possess no underbasals, and he for a similar reason admitted *Lyriocrinus* among the Calyptocrinidæ.

The Glyptocrinidæ and Rhodocrinidæ of Zittel, according to his own diagnosis, differ only in the form of the body and the position of the interradial (not anal) plates. He describes the form of the Glyptocrinidæ as high (turbinate), that of the other bowl-shaped (more or less depressed), the first interradials of the former as being placed between the second and third radials, those of the latter as forming together with the first radials a ring of ten alternating plates. We doubt very much whether these differences, even if they were persistent, can be deemed sufficient for a family distinction. *Thysanocrinus* of the Rhodocrinidæ has generally at four sides the first interradial disposed between the first and second radials; while in *Thylacocrinus*, according to Oehlert's figure, all five first interradials rest directly upon the basals, or to use Zittel's language, "form a ring of ten plates with the first radials as in his *Rhodocrinidæ.*"

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[1] Traité de Paléont., 1857, vol. iv.

[2] Lethæa Geogn., 1855 (Ausg. 3).

[3] Handbuch der Palæontologie, i.

In our classification, we place under the Rhodocrinidæ all genera of the Sphæroidocrinidæ which have well-defined underbasals, and we admit also *Glyptocrinus* in which these plates are exceedingly rudimentary, or perhaps in some species altogether undeveloped. The Rhodocrinidæ have five—exceptionally three—basals; from 2 to 3 × 5 primary radials, 2 to 6 × 10 secondary and sometimes several tertiary radials. The plates of the higher orders, if such are present, being formed into extended free rays with lateral arms. Arms rather delicate, branching or simple, the latter being rather the exception. Interradials numerous, arranged with two or three plates in each series, except in the first which has but one plate. In most of the genera, the first interradial rests directly upon the truncate upper side of the basals, thereby separating the first radials all around. In others, however, only the first plate of the posterior or anal side is supported by a basal, that of the other four sides being placed against the upper corners of the first and between the second radials, the former producing an almost perfect pentrahedral, the latter a more or less bilateral symmetry.

In *Glyptocrinus*, the first interradial rests between the first and second radials at every side; interaxillaries generally present; vault flat or low hemispherical, composed of small and more or less irregular pieces; apical dome-plates not well defined; interradial regions depressed; anus in form of a simple opening through the vault, rarely proboscis-like. Column round or pentagonal.

For greater convenience of study we subdivide the Rhodocrinidæ into three groups.

a. Glyptocrinites.—Calyx turbinate, symmetry almost perfectly pentahedral, radial plates with rounded, strongly elevated ridges which gently pass into the arms. Interradial areas depressed, the first plate resting either directly upon the basals, or between the second and third radials, without special anal plate beneath their line. Restricted to the Lower Silurian.

b. Glyptasterites.—Calyx turbinate, symmetry bilateral, radials less carinated than in the preceding group. A special anal plate supported upon the basals, with another within the second series, resting between the two interradials, and in line with the first interradial plate of the four lateral areæ. Upper Silurian.

c. Rhodocrinites —Calyx subglobose, somewhat depressed; symmetry nearly perfectly pentahedral. Radials without elevated ridges. Interradial plates extending down to the basals, posterior area but little distinct from the others, sometimes a little wider, with one or two irregular additional plates. Found from the Upper Silurian to the Subcarboniferous.

These groups, as those of the Actinocrinidæ, are based upon the general form of the body and the arrangement of anal plates. In their form, the *Glyptocrinites* resemble the *Glyptasterites*, but in the arrangement and position of interradial and radial plates the former agree with the *Rhodocrinites.* It might have been not out of the way if we had placed the genus *Glyptocrinus* in a group by itself, as it differs from *Archæocrinus* and *Reteocrinus*, with which it has been associated, and from all other Rhodocrinidæ, in having the first plate at each interradial side placed between the second radials, a combination which is found not unfrequently in the earlier Actinocrinidæ. This becomes more important since some species of that genus apparently have no underbasals, and it is a question whether that genus, at least partly, should not be arranged with the other group altogether. The unmistakable evidence of minute underbasals in some species, and the close affinities which the genus has with *Reteocrinus*, with which it is connected by most remarkable transition forms, has induced us to place it with the Rhodocrinidæ. *Glyptocrinus* evidently forms a link between those two great divisions, and leans as much to the one as to the other, but whether it is the prototype of the Actinocrinidæ or of the Rhodocrinidæ we are unable to assert, there being arguments in favor of both theories. It seems to us more probable that the Rhodocrinidæ were introduced first, but this must remain a supposition so long as we know comparatively nothing of the crinoidal forms which preceded *Glyptocrinus.*

The arms of the Rhodocrinidæ in the Lower Silurian, are single- or double-jointed; the Upper Silurian forms, almost without exception, have two rows of interlocking plates. Respiratory pores, such as noticed in the Actinocrinidæ, have never been observed in this family; *Ollacrinus* has lateral appendages, two to each interradial area, with a central canal passing through each, communicating with the inner body. The entrances of these canals into the body occupy the same relative position to the ambulacral or arm openings, as the respiratory pores to the arm openings in *Batocrinus*, and these like those are connected with the radial grooves beneath the vault. The appendages seem to be in some way connected with the interradial depressions which are so frequently found upon the vault of this genus and in *Rhodocrinus* (Pl. 19, fig. 1). The depressions are in some specimens deeper than in others, and as the plates of which they are composed are smaller and thinner, it is very probable that the test in these parts was flexible, liable to contraction and expansion.

Geological Position, etc.—Nine of the thirteen genera which we place among the Rhodocrinidæ are restricted to the Silurian, two are strictly Devonian, and the remainder which first appear in the Devonian, become extinct in the lower part of the Subcarboniferous. None of the genera seem to have had a great variety of species or to have existed in great numbers, except some few species of the Lower Silurian.

We arrange the three sections as follows:—

a. Glyptocrinites.

1. *Glyptocrinus* Hall.
2. *Archæocrinus* Wachs. & Spr.
3. *Reteocrinus* Billings.

b. Glyptasterites.

4. *Glyptaster* Hall.
   Subgen. *Eucrinus* Angelin.
5. *Dimerocrinus* Phillips.
6. *Lampterocrinus* Roemer.
7. *Sagenocrinus* Austin.

c. Rhodocrinites.

8. *Lyriocrinus* Hall.
9. *Ripidocrinus* Beyrich.
10. *Thylacocrinus* Oehlert.
11. *Anthemocrinus* Wachs. & Spr.
12. *Rhodocrinus* Miller.
13. *Ollacrinus* Cumberland.

P. S.—At the moment this goes to press, we received from S. A. Miller a very interesting paper containing descriptions of several new Crinoids from the Hudson River group, published in the April number of the Journ. Cincin. Soc. Nat. Hist. Miller proposes the name *Xenocrinus* for a form, which in external appearance resembles closely *Reteocrinus* Billings, but from which it differs, according to description, by having a quadrangular column, four basals and no underbasals, thus bringing it in close proximity to *Mariacrinus* and *Melocrinus*, and among the Actinocrinidæ. There is something in the habitus of the genus that leads us to think it should be associated with the Rhodocrinidæ, and that it had underbasals which were not disclosed.

No Actinocrinoid has ever been discovered in which the interradial field, except at the "azygous" side, extends to the basal disk; such, however, seems to be clearly the case in *Xenocrinus penicillus.* We leave the discussion of this genus to our future appendix, as we hope to have an opportunity to examine some of the specimens.

Another of Miller's new species is described with four basals and a quadrangular stem; but, contrary to the former, here only the interradial area at the posterior or anal side descends to the basals. Miller refers the species to *Glyptocrinus* with which it has no doubt close affinities, but it appears to us, that if *Xenocrinus* is a good generic form, the other also should be made a new genus. *Gl. Harrisi* is distinguished from *Glyptocrinus* almost by the same characters as *Xenocrinus* from *Reteocrinus.* We further refer *Glyptocrinus cognatus* Miller, to *Reteocrinus.*

a. GLYPTOCRINITES.

1. GLYPTOCRINUS Hall.

1847. Hall. Paleont. New York, i, p. 281.
1857. Billings. Geol. Surv. Canada, of 1853 to 1856, p. 256.
1859. Billings. Ibid., Decade iv, p. 55.
1863. Hall. Trans. Albany Inst., iv, p. 202.
1873. Meek. Geol. Surv. Ohio Paleont., i, p. 30.
1879. Zittel. Handb. d. Paleont., i, p. 374 (not *Glyptocrinus* d'Orb., 1850, Prodr. i, p. 45, nor p. 103).
Syn. *Apiocrinite* Anthony, 1838 (not Miller, 1821).
Syn. *Icosidactylocrinus* Owen, 1843, Cat. Spec. Ohio Valley.

We are compelled to exclude from the genus *Glyptocrinus* several species which were referred to it by Hall and Billings, and have arranged them with other genera. We place *Glyptocr. Carleyi* Hall—which has four basals and not five—under *Mariacrinus* as reconstructed and amended by us. The generic differences between *Glyptocrinus* and *Glyptaster* have never been satisfactorily pointed out, and Hall's explanatory remarks (Trans.

Albany Inst., iv, p. 202) have by no means cleared up the difficulties attending their separation.

According to Hall, the principal distinction should be found in the rudimentary or imperfect condition of the underbasals in *Glyptocrinus*, as opposed to the moderately large size of the same pieces in *Glyptaster*, and in that the rays of the former were twice subdivided in the body, with simple undivided arms, while the latter had but a single division in the body. A comparison of all the species that have been referred to *Glyptocrinus*, shows conclusively that these supposed distinctions are not borne out by the facts. Hall's so-called *Glyptocr. O'Nealli* has well defined underbasals, and the second branching of the ray takes place in the free arms, while the rays in *Glyptocr. nobilis* divide at least three times in the body, and on the other hand in *G. Dyeri* Meek, the second bifurcation takes place in the arms. We have placed *G. O'Nealli* Hall, *G. Richardsoni* and *G. gracilis* Wetherby, *G. Baeri* Meek, and *G. cognatus* Miller, under *Reteocrinus* Billings, and should have proposed *G. nobilis* the type of a new genus, if we had before us good specimens instead of figures of casts in which neither basal nor anal plates are shown. The high dome, the anal tube, the large number of arms, and its occurrence in a different geological horizon suggests very strongly to our mind its generic distinctness.

Glyptocrinus is one of the oldest forms of the Rhodocrinidæ, and is the forerunner and type of a little group of Silurian Crinoids, which are readily recognized by their obconical form; the prominent rounded ridges that follow the radial series of the calyx, ooking like recumbent arms; the beautifully striated surface, and the character of the arm structure. The arms in all of them rise from the edge of the vault, forming uninterrupted prolongations of the elevated ridges of the calyx, and the radial plates pass into arm plates so gradually, that it becomes almost impossible to discern where the calyx terminates and the arms begin. Zittel has arranged these genera into a distinct family and we should follow his example if we had not discovered that the same characters exist among the Actinocrinidæ, and indeed—what is more significant—among genera with five, four and three basals, but only in Silurian types, thus indicating that the characters above noted represent probably a younger stage of family development.

Glyptocrinus differs from *Glyptaster* in having rudimentary instead of moderately developed underbasals, in not having the first anal plate on a level with the first radials, and in the arms, which in *Glyptocrinus* are composed of single joints, instead of two rows of interlocking pieces as in *Glyptaster*. *Reteocrinus* differs in the size of its underbasals, the deeply depressed inter radial spaces, the irregular arrangement, and exceedingly large number of interradial and interaxillary plates, and that the rays are not connected laterally, but, all the way up from the basals, separated by small interradial pieces.

We propose for *Glyptocrinus* the following:

Revised Generic Diagnosis.—Calyx obconical to subglobose, its symmetry almost perfectly pentahedral. Surface ornamented with radiating striæ in form of elevated ridges, which divide into numerous triangular impressed areæ. The ridges passing along the radial portions are rounded, nearly as wide as the arm joints, and appear like arms that are soldered into the body. The arms rise vertically from the edge of the vault, forming undisturbed continuations of the ridges of the calyx, and the higher radial plates pass imperceptibly into arm plates.

Underbasals five, rudimentary—perhaps sometimes obsolete—entirely hidden from view by the column, and filling only a small portion of the basal concavity. Basals five, of uniform size, small, scarcely extending to the sides of the body, slightly concave for the attachment of the column. Primary radials 3 × 5, the lower series somewhat larger, nearly similar in form; the second hexagonal; the third pentagonal in outline, and supporting on its upper sloping sides the secondary radials. The number of secondary radials varies with the species, but, as a general rule, it might be asserted, that in species with a third order of radials or a second division within the body, there are only two secondary radials, while in species in which the second bifurcation takes place in the free arms, their number is much greater. Species of the latter kind sometimes have six, eight or more, and these are succeeded to the last bifurcation by three, four or more free plates. The tertiary radials, where they exist, are as variable in number as those of the secondary order. There may be within the same species one, three or more of these plates soldered into the body, or they all may be free plates, depending on the age of the individual.

Arms twenty, rising upright, almost vertically from the last radial, long, slender, simple from the second division, rounded on the outer side, and composed of a single series of short, somewhat wedge-shaped pieces, of which each one supports at its larger end a pinnule. Pinnules very slender, alternately and very closely arranged, the proximal ones fixed in the body walls, the first generally given off from the second secondary radials.

Interradial areæ occupied by a large number of pieces, arranged in four or more series, with one plate in the first, two in the second, and generally three in each succeeding series. The posterior or anal area differs from the others in being a trifle wider, and having three plates instead of two in the second and all succeeding series. The median row generally consists of larger plates, and these elevated above the level of the others. The first anal, like the first interradial plate, rests upon the upper sloping side of the first and between the second radials. Interaxillary plates from one to ten, with a less number in species in which the last bifurcation takes place in the body.

Vault scarcely elevated above the horizon of the arm bases; the interradial regions somewhat depressed; composed of numerous very small, convex plates. The apical dome plates not well defined; anal aperture directly through the vault, excentric.

Column round, of medium size; central canal small, distinctly pentagonal.

Geological Position, etc.—*Glyptocrinus*, as amended by us, occurs exclusively in the Lower Silurian at the age of the Trenton and Hudson River groups, and apparently only in America.

We recognize the following species:—

1879. **Glyptocrinus angularis** Miller and Dyer. Jour. Cincin. Soc. Nat. Hist., p. 5, Pl. 1, fig. 10. Hudson River gr. Cincinnati, Ohio.

1847. **Glyptocr. decadactylus** Hall. Type of the genus. Paleont. N. York, i, p. 281, Pl. 77, figs. 1 a–f, and Pl. 78, figs. 1 a–u; also Geol. Rep. Ohio, Paleont., i, p. 30, Pl. 2, figs. 5 a, b; Zittel, Handb. der Palaeont., i, p. 375, figs. 262. Hudson River gr. Cincinnati, Ohio.

1872. **Glyptocr. Dyeri** Meek. Proc. Acad. Nat. Sci. Phila., p. 314; also Geol. Rep. Ohio, Paleont., i, p. 32, Pl. 2, figs. 2 a, b (not 2 c). Hudson River gr. Cincinnati, O.

1855 (?) **Glyptocr. fimbriatus** Shumard. Geol. Rep. Missouri, by Swallow, pt. ii, p. 194, Pl. A, figs. 10 a, b. Trenton gr. Cape Girardeau, Mo.

This species evidently does not belong to **Glyptocrinus**, description and figure are too imperfect to place it correctly.

1874. **Glyptocr. Fornshelli** S. A. Miller. Cincin. Quart. Journ. Sci. Hudson River gr. Cincinnati, Ohio.

1861 (?) **Glyptocr. nobilis** Hall. Rep. of Progress, Geol. Rep. Wis., p. 21; also 20th Rep. N. York St. Cab. Nat. Hist., 1867, p. 21, Pl. 10, figs. 9, 10. Niagara gr. Racine, Wis.

(See our remarks under **Glyptocrinus** and **Lampterocrinus.**)

1857. **Glyptocr. ornatus** Billings. Geol. Rep. Canada (Rep. of Progress), p. 260; Ibid., 1859, Decade iv, p. 60, Pl. 9, figs. 2 a, b. Trenton limest. Ottawa, Canada.

1872. **Glyptocr. parvus** Hall. Desc. New Crin., etc., pt. i, fig. 17, (without description); 24th Rep. N. York St. Cab. Nat. Hist., p. 207, Pl. 6, fig. 17; Meek, 1873, Geol. Rep. Ohio, Paleont., i, p. 36, Pl. 2, figs. 4 a, b. Hudson River gr. Cincinnati, Ohio. (Perhaps a young **G. decadactylus.**)

1857. **Glyptocr. priscus** Billings. Geol. Rep. Canada (Rep. of Progress). p. 257; also, 1859, Ibid., Decade iv, p. 56, Pl. 7, figs. 1 a–f. Trenton limest. Ottawa, Canada.

1857. **Glyptocr. ramulosus** Billings. Geol. Rep. Canada (Rep. of Progress), p. 258; 1859, Ibid., Decade iv, p. 57, Pl. 7, figs. a–f and Pl. 8, figs. 1 a–e. Trenton limest. Ottawa, Canada.

1875. **Glyptocr. Shafferi** S. A. Miller. Cincin. Quart. Journ. Sci., vol. ii, p. 277; Journ. Cincin. Soc. Nat. Hist., 1880, Oct., p. 3, Pl. 7, fig. 3. Hudson River gr. Cincinnati, Ohio.

If this is a **Glyptocrinus**, it evidently is a very young specimen.

Syn **Glyptocr. Shafferi** var. **Germanus** Miller. Journ. Cincin. Soc. Nat. Hist., 1880, Oct., p. 3, Pl. 7, fig. 2.

*1872. **Glyptocr. subglobosus** Meek. (**Glyptocr. Dyeri** var. **subglobosus**) Proc. Acad. Nat. Sci. Phila., p. 314; also Geol. Surv. Ohio, Paleont., i, p. 34, Pl. 2, fig. 2 c. Hudson River gr. Cincinnati, Ohio.

We take this to be an independent species, and not a variety of **G. Dyeri**, it may possibly prove to be a **Reteocrinus.**

2. ARCHÆOCRINUS Nov. gen.

(αρχαῖος ancient, κρῖνον a lily.)

Among the species described in the Canada Report by Billings as *Rhodocrinus* and *Glyptocrinus*, there are several which cannot be brought under either of these, or any other known genus. They differ from *Glyptocrinus* in their larger size, their surface ornamentation, in having the first radial plates separated by interradials, in their shorter and branching arms, and in having them constructed of a double series of wedge-form pieces. They differ from *Reteocrinus* in having smaller underbasals, in having the interradial plates systematically arranged, of a less number, and larger size, and also in the arm structure; from *Rhodocrinus* in the general form of the body, in the large number of secondary radials, and the elevated ridges passing gradually and vertically into arms, which do not spring off laterally from the body as in the latter genus.

We propose for this little group, which is one of the oldest of the known Crinoids, the name "*Archæocrinus*" and make Billings' *Glyptocrinus lacunosus* the type of the genus.

Generic Diagnosis.—Calyx large, pear-shaped, sometimes obconical; plates smooth or granulated; the radial plates with keel-like elevations along their median line, but less prominently than in *Glyptocrinus*, and the carinæ narrower.

Underbasals five, pentagonal, rather small and rarely extending beyond the column. Basals five, hexagonal, with a truncate upper side, supporting the first radial plates. Primary radials 3 × 5, of medium size, gradually decreasing upward, width and height about equal. They support two rows of secondary radials of three to four plates in each row, which are followed in the same line by the arm plates, all further divisions of the rays taking place in the arms. The rays are widely separated by large interradial areæ. Arms short, slender, the branches divergent; composed of two rows of cuneiform pieces, alternately arranged and interlocking. Interradial areæ large; resting directly upon the upper truncate side of the basals, and passing gradually into vault pieces. The plates of the two proximal series are generally of equal size, all succeeding ones are much smaller. There are two plates in the second series in all five areæ, those at the posterior side are probably a little wider. Interaxillaries represented by one or more plates.

Vault and anus unknown. Column round.

Geological Position, etc.—*Archæocrinus* is only known from the Lower Silurian of America.

We place here the following species :—

*1857. **Archæocrinus lacunosus** Billings. Type of the genus. (**Glyptocr. lacunosus**) Geol. Rep. Canada (Rep of Progress), p. 261; Ibid., 1859, Decade iv, p. 61, Pl. 8, figs. 3 a–e. Trenton limest. Ottawa, Canada.

*1857. **Archæocr. marginatus** Billings. (**Glyptocr. marginatus**) Geol. Rep. Canada. (Rep. of Progress), p. 260; Ib., 1858, Decade iv, p. 59, Pl. 9, figs. 1, 1 a. Trenton limest. Ottawa, Canada.

*1857. **Archæocr. microbasilis** Billings. (**Thysanocr.—Rhodocr.—microbasilis**) Geol. Rep. Canada (Rep. of Progress), p. 264; Ibid., 1859, Decade iv, p. 63, Pl. 6, fig. 2. Trenton limest. Ottawa, Canada.

*1857. **Archæocr. pyriformis** Billings. (**Thysanocr.—Rhodocr.—pyriformis**) Geol. Rep. Canada (Rep. of Progress), p. 262; Ibid., 1859, Decade iv, p. 61, Pl. 6, figs. 1 a–d. Trenton limest. Montreal, Canada.

3. RETEOCRINUS Billings.

1859. Billings. Geol. Rep. Canada, Decade iv, p. 63.
Syn. *Glyptocrinus* (in part), Hall 1866 and 1872; Meek 1873.

Among the species described by Hall under *Glyptocrinus*, there is one—*Gl. O'Nealli*—which in several important characters differs from his typical form. It has well-developed underbasals, very large basals, a pentagonal stem, and exceedingly depressed interradial and anal regions, peculiar radial plates, etc., in all of which characters it agrees with the genus *Reteocrinus* Billings, which was described from imperfect material, and altogether misunderstood by its founder. According to Billings, the calyx consists of a reticulated skeleton, composed of incomplete or rudimentary plates, each consisting of a central nucleus with three to five stout processes radiating from it. Of such plates he describes three rings of five each, corresponding in their position with the underbasals, basals and first radials of other crinoids, and he compares the genus with *Cyathocrinus*, *Dendrocrinus* and similar forms.

This description at first glance does not agree with *Gl. O'Nealli*, but a closer comparison with *Reteocr. stellaris* Billings shows at once a remarkable similarity in the form and arrangement of these rudimentary plates with the principal plates of the former species, and leads to the conclusion that the interradial plates, which are said to be wanting in *Reteocrinus*, really exist there, but are so deeply imbedded within the depression as to be hidden from view by the matrix. Even in *Glyptocr.* (?) *O'Nealli*, the construction of the interradial spaces is but rarely observed. Looking at the specimens in the condition in which they are generally found, they agree remarkably well with Billings' description. The second and third primary radials appear to be free plates, and the calyx seems to be composed of only three rings of plates like in the Cyathocrinidæ.

The resemblance of *Gl. O'Nealli* with the genus *Reteocrinus*, was pointed out already by Meek (Paleont. of Ohio, i, p. 34), but he left the species under *Glyptocrinus;* also Wetherby noticed this similarity in the description of his *Glyptocr. Richardsoni*, and he agrees with us, that both his species and *Gl. O'Nealli* should be arranged under *Reteocrinus.*

A reconstruction of the genus with *Gl. O'Nealli* = *Reteocr. O'Nealli*, as type, will, we believe, clear up a number of difficulties, and we accordingly propose the following:—

Revised Generic Diagnosis.—Calyx obconical, its symmetry somewhat bilateral; interradial and interaxillary spaces profoundly depressed; radial plates highly elevated into strong rounded ridges, which in outer appearance resemble arms; they bifurcate and follow the secondary radials, whence they pass gradually into free arm joints.

Underbasals five, well developed, extending beyond the column. Basals five, large, protuberant, hexagonal, the upper side slightly truncate and supporting the first series of interradial plates; the upper portions inflected, and involved in the interradial depressions.

Radials 3 × 5, those of different rays separated by interradials; the first and third pentagonal, the second quadrangular, as long as the two former ones but narrower. The radials are highly elevated, forming a broad rounded ridge, which from the third radial branches upward, following the secondary radials, and downward from the first primary radials toward the basals. This branching gives to the first and third radials a similar form, only the direction of the branches reversed, the truncation taking place from reversed sides of the plates. Secondary radials four to five in the adult, a less number in young specimens; decreasing in height upwards, quadrangular, shaped like arm joints, and like them giving off pinnules, which in the adult are incorporated[1] within the body.

Arms ten, long, slender, rounded, bifurcating, composed of a single series of rectangular or slightly wedge-formed pieces, which give off on alternate sides rather stout, closely arranged pinnules. Interradial series resting directly upon the basals, consisting of a very large number of minute pieces, of irregular form, and without definite arrangement; the posterior area wider, with a conspicuous row of decidedly larger and more prominent special anal pieces along the median part. Interaxillary plates almost as numerous as the interradials, and of a similar character. The peculiar depressed state of the interradial and interaxillary areæ, the irregularity with which their plates are arranged, suggests the possibility that they were adapted to expansion by the animal.

Vault composed of numerous, very small and convex pieces, with an elevation running to each arm base; the plates in the median part, which probably include the apical plates, somewhat larger. Anal aperture directly through the vault, small, subcentral.

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[1] See our remarks upon fixed pinnules in our general notes upon the Sphæroidocrinidæ.

Column subpentagonal, its lateral faces but little depressed; central canal rather large.

Geological Position, etc.—*Reteocrinus* belongs to the age of the Trenton and Hudson River groups, and is only found in America.

We place here the following species :—

*1872. **Reteocrinus Baeri** Meek. (**Glyptocr. Baeri**) Amer. Journ. Sci. and Arts, iii (Ser. 3), p. 260; also 1873, Geol. Rep. Ohio, Palæont., p. 37, Pl. 2, fig. 1 a, b. Upper part of Hudson Riv. gr. Richmond, Ind.

*1881. **Reteocrinus cognatus** S. A. Miller. (**Glyptocr. cognatus**) Journ. Cincin. Soc. Nat. Hist. (April No.), p. 7, Pl. 1, fig. 5. Hudson River gr. Middletown, Ohio.

*1859. **Reteocr. fimbriatus** Billings. Geol. Rep. Canada, Decade iv, p. 65, Pl. 9, figs. 3 a, b, c. Hudson River gr. Island of Anticosti.

*1881. **Reteocr. gracilis** Wetherby. (**Glyptocr. gracilis**) Now in press. Cincin. Journ. Nat. Hist., Pl. ii, figs. 2, 2 a. Hudson River gr.

*1866. **Reteocr. O'Nealli** Hall. Proposed type of the genus. (**Glyptocr. O'Nealli**) Desc. New Sp. Crin., p. 2; also 24th Rep. N. Y. St. Cab. Nat. Hist., p. 206, Pl. 5, figs. 18, 19; Meek, 1873, Geol. Rep. Ohio, Paleont., i, p. 34, Pl. 2, figs. 3 a, b, c. Upper part of the Hudson River gr. Lebanon, O.

*1880. **Reteocr. Richardsoni** Wetherby. (**Glptocr. Richardsoni**) Journ. Cincin. Soc. Nat. Hist; Desc. New Crin. Cincin. gr., Pl. 16, figs. 1 a-e. Hudson River gr. Clinton Co., Ohio.

*1859. **Reteocr. stellaris** Billings. Geol. Rep. Canada Dec., iv, p. 64, Pl. 9, figs. 4 a-e. Trenton limestone. Ottawa, Can.

b. GLYPTASTERITES.

4. GLYPTASTER Hall.

1852. Hall. Paleont. N. York, ii, p. 187.
1863. Hall. Trans. Albany Inst., iv, p. 202.
1879. Hall. 28th Rep. N. Y. St. Cab. Nat. Hist. (ed. ii), p. 133.
1879. Zittel. Handb. der Palæont., i, p. 375.

The genus *Glyptaster* is involved in some confusion. It was founded upon a specimen from the Niagara group of New York, which Hall named *Glyptaster brachiatus*. In the type specimen, the plates of the calyx are altogether obscure except possibly the basals, which were stated to be five in number. The specimen further showed five highly elevated ridges along the radial portions of the calyx, and ten long, slender arms, which are composed of a double series of interlocking joints, and spread out horizontally at right angles to the walls of the body, without bifurcations, and, according to figure, without pinnules.

Judging from this description, the double-jointed arms are the only characters which distinguish the genus from *Glyptocrinus*. The next two species referred to *Glyptaster* were *G. occidentalis* and *G. inornatus*, both described by Hall from the Niagara gr. of Waldron, Ind. In these specimens, which are found rather abundantly, only the calyx was preserved, while the vault and arms remained unknown, thus leaving it somewhat doubtful whether the two Waldron species may not be generically distinct from the New York form.

Glyptaster is closely allied to *Eucrinus* Angelin, indeed so closely, that we have some doubt whether the two should not be altogether united instead of being separated subgenerically, as now pursued by us. So far as known, the latter form differs only in having tertiary radials and additional arms. It is possible that *Glyptaster pentangularis* Hall and *Glyptocr. armosus* McChesney belong to the subdivision, the two species are only known from internal casts, which are unreliable for purposes of identification, unless accompanied by a cast of the external mould.

In a very interesting specimen of *Glyptaster inornatus*, kindly loaned us by Mr. Wm. F. Gurley, of Danville, Ill., and the only specimen known to us in which the vault and anal aperture have been found preserved, we notice in two of the rays on the side toward the interradial spaces, and enclosed by them, a highly elevated fixed pinnule. The specimen is of comparatively large size, and as the interradials in this species have no conspicuous surface markings, these pinnules are readily recognized. Both are given off from a first secondary radial, which thereby takes the form and aspect of a bifurcating plate. The first joint of the pinnule is rather large, and the ridge or elevation upon the plate is about one-half the width of that upon the radials. Two more joints follow, likewise enclosed within the body walls, and having a ridge equally conspicuous, though narrower. From the first joint of the pinnule is given off another or secondary pinnule, fixed like the other but more slender, and composed of at least two joints. The first plate of the primary pinnule has altogether the appearance of a tertiary radial, and is given off in a like manner, but the succeeding plates, though somewhat larger than common, resemble more those of ordinary pinnules, or may be described as intermediate between fixed pinnule plates and radials. This is but an abnormal case, but it gives some idea how in the course of time, among species, bifurcating radials became developed from pinnule-bearing plates, and additional arms from the proximal pinnules.

Generic Diagnosis.—Form of calyx subturbinate or obconical; strongly depressed between the arm bases; plates delicate, beautifully ornamented with granules and striæ, the radial portions with strong ridges or costæ; anal area very wide, and hence symmetry distinctly bilateral.

Underbasals five, small but not rudimentary, and generally extending beyond the column. Basals five, four of them equal with the upper side angular, the fifth larger with a truncate upper side for the support of the first anal plate. Primary radials 3 × 5, width and height nearly equal, decreasing in size upward. The third radials support two rows of secondary radials, which are separated by one to three interaxillary plates, the latter being perhaps absent in young specimens. The number of secondary radials, like in the *Glyptocrinites*, is variable, differing among species, and increasing with age in the individual; their exact number is rarely ascertained, as they pass gradually into brachials and regular arm plates.

Arms ten, simple? and composed of two rows of interlocking pieces with pinnules.

Interradial areæ large, and, compared with the preceding genera, composed of fewer and larger plates. There is one plate in the first series, which rests between the two upper sides of two first and between two second radials; two in the second series, on a level with the third radials, with much smaller plates above, which connect with the interradial portions of the dome.

Anal area distinctly wider. The first anal plate resting upon the truncate posterior basal, and between two adjoining first radials; there are three plates in the second, and four or five in each succeeding series. Above the level of the third primary radials the plates are bent somewhat inward, the anal area is in the middle elevated into a low ridge, at the sides depressed.

The vault which is only known in *Glyptaster inornatus* is decidedly pentalobate, and resembles *Dorycrinus* in the anal region. Anal opening excentric, protruding and reaching somewhat beyond the limits of the vault, not extended into a tube.

Apical dome plates well defined but somewhat displaced, owing to the great number of plates which surround the anus. Radial regions of the dome prominent, in form of five high ridges which bifurcate, sending a branch to each arm. They are composed of two rows of rather large convex and elongate plates, transversely arranged, which in branching separate, and pass on as two single rows of plates.

Interradial dome regions depressed, and composed of small irregular pieces.

Column round; central canal of medium size.

Geological Position, etc.—*Glyptaster* is known only from the Niagara group, Upper Silurian, of America.

We recognize the following species:—

*1861 (?). **Glyptaster armosus** McChesney. (**Eucalyptocr armosus**) Desc. New Pal. Crin., p. 95; also 1867, **Glyptocr.** (?) **armosus,** Chicago Acad. Sci., p. 23, Pl. 7, fig. 6; Hall, 20th Rep. N. Y. St. Cab. Nat. Hist., Pl. 10, fig. 11. Niagara limest. Racine, Wis.

Syn. **Glytocr. siphonatus** Hall. (Nov.) 1861, Geol. Rep. Wis., p. 22; 20th Rep. N. Y. St. Cab. Nat. Hist., p. 328, Pl. 10, fig. 11.

Gl. armosus was described from internal casts, and there is some doubt as to its specific and even generic character.

1852. **Glyptaster brachiatus** Hall. Type of the genus. Paleont. N. Y., ii, p. 187, Pl. 41, fig. 4. Niagara gr. Lockport, N. Y.

1863. **Glyptaster inornatus** Hall. Trans. Alb. Inst., iv, p. 205; also 28th Rep. N.Y. St. Cab. Nat. Hist., 1879 (ed. ii), p. 134, Pl. 14, figs. 1–6. Niagara gr. Waldron, Ind.

1863. **Glyptaster occidentalis** Hall. Trans. Alb. Inst., iv, p. 204; also 20th Rep. N. Y. St. Cab. Nat. Hist., p. 305, and 28th Rep. 1879 (ed. ii), Pl. 13, figs. 7, 11. Niagara gr. Waldron, Ind., and Racine, Wis.

1864. (?) **Glyptaster pentangularis** Hall. 20th Rep. N. Y. St. Cab. Nat. Hist., p. 326, Pl. 10, fig. 3 (advance sheets 1864). Niagara gr. Racine, Wis.

The species was described from casts, but probably belongs to this genus.

Subgenus **EUCRINUS** Angelin.

1878. Angelin. Iconogr. Crin. Suec., p. 24.

1879. Zittel. Handb. der Palæont., i, p. 375.

Syn. *Rhodocrinus* Schultze 1866 (in part). Echin. Eifl. Kalk, p. 57.

Syn. *Dimerocrinus* (in part) Phillips, 1839; d'Orbigny, 1850 and 1852; Pictet, 1857.

Eucrinus agrees with *Glyptaster* in the form of the calyx, the style of ornamentation, and size and form of underbasals. It also has 3 × 5 primary radials, and an elevated ridge all along the radial regions, but differs in having tertiary radials—from one to two or more—and four arms to each ray. There is no departure in the arrangement of the interradial plates, the first anal stands in line with the first radials, and is succeeded by three plates in the second series, and other plates above.

In all known species, the median row of anal plates is arranged longitudinally, somewhat curved toward the margins, and slightly elevated in form of a ridge above the general level of the other plates, as in the case of *Glyptaster inornatus* and several other species.

We place here Schultze's *Rhodocr. quinquelobus*, it being the only species of this group in which the construction of the vault is known. The dome is composed of small plates, central dome plate crowned with a short spine, anus excentric, almost lateral, and not prolonged into a proboscis.

Arms are rather strong, composed of two series of interlocking pieces.

Column round; central canal of medium size.

Geological Position, etc.—*Eucrinus* has been found in Sweden in rocks of the Upper Silurian, in Germany in the Stringocephalenkalk of the Eifel. Two of Angelin's species have been referred to our new genus *Anthemocrinus*. We recognize only the following species:—

*1839. **Eucrinus icosidactylus** Phillips. (**Dimerocr. icosidactylus**) Murchison's Silur. Syst., p. 673, Pl. 17, fig. 5; D'Orbigny, 1850, Prodr. de Paléont., i, p. 46; Pictét, Traité de Paléont., iv, p. 142. Upper Silurian. Dudley, Eng.

1878. **Eucr. interradialis** Angelin. Iconogr. Crin. Suec., p. 25, Pl. 6, fig. 6, and Pl. 19, figs. 1, 7, 8. Upper Silurian. Gothland, Sweden.

1878. **Eucr. lævis** Angelin. Type of the genus. Iconogr. Crin. Suec., p. 25, Pl. 6, figs. 8, 8 a. Upper Silurian. Gothland, Sweden.

1878. **Eucr. quinquangularis** Angelin. Iconogr. Crin. Suec., p. 25, Pl. 10, figs. 5, 14. Upper Silurian. Gothland, Sweden.

*1867. **Eucr. quinquelobus** Schultze. (**Rhodocr. quinquelobus**) Echin. Eifl. Kalk, p. 57, Pl. 7, fig. 6. Devonian. Eifel, Germ.

1878. **Eucr. ornatus** Angelin. Iconogr. Crin. Suec., p. 25, Pl. 6, figs. 7 a, b. Upper Silurian. Gothland, Sweden.

1878. **Eucr. speciosus** Angelin. Iconogr. Crin. Suec., p. 25, Pl. 19, figs. 2, 2 a, and Pl. 23; figs. 7 a, b, and Pl. 26; figs. 26, 26 a, and Pl. 27; fig. 2. Upper Silurian. Gothland, Sweden.

5. DIMEROCRINUS Phillips.

1839. Phillips. Murchison's Silur. Syst., p. 674 (in part).
1841. Müller. Monatsber. Berl. Akad., i, p. 208 (in part).
1850. D'Orbigny. Prodr. de Paléont., i, p. 46 (in part).
1852. D'Orbigny. Cours. élém. de Paléont., ii, p. 142 (in part).
1857. Pictét. Traité de Paléont., iv, p. 318 (in part).

1879. Zittel. Handb. der Palæont., i, p. 368 (in part).
(Not Pacht, 1853. Verh. Kaiserl. Russ. Gesellsch., p. 262.)
Syn. *Thysanocrinus* Hall, 1852. Paleont. N. York, ii, p. 188.
(Not *Thysanocrinus* (*Rhodocr.*) Billings. Geol. Surv. Canada for 1853 to 1856, p. 262.)

The name *Dimerocrinus* was given by Phillips to two species from Dudley, England, which are known as *D. decadactylus* and *D. icosidactylus*, and which were figured without specific or generic definition. The genus has been generally accepted, but is since described as having only one ring of plates beneath the radials, and this variously by different writers as composed of either three or five plates.

We have carefully examined the two species, and find that they both have underbasals. Those of *D. decadactylus* are placed within a rather deep concavity, formed between the basals and hidden by the column, exactly as some species described and figured by Hall under his genus *Thysanocrinus*, which we take to be a synonym of *Dimerocrinus*. Phillips' *D. icosidactylus* is generically distinct, and has been referred by us to *Eucrinus*. Very closely allied is *Patelliocrinus* Angelin, which Zittel unites with *Dimerocrinus;* the two genera resemble each other most remarkably, but the former can readily be separated by its three basals and the absence of underbasals.

Generic Diagnosis.—Body small, calyx short, subglobose or conical; plates not numerous, surface less ornamented than in the preceding genera, smooth or indistinctly granulose; symmetry bilateral.

Underbasals five, small, arranged within a concavity, which is nearly or entirely filled by the column. Basals five, four of them equal, angular above; the fifth truncate and supporting the first anal plate. Primary radials 3 × 5; the first almost as large as the second and third together and considerably wider, the two lower sides making an angle, which rests deeply between the basals; lateral sides short, the first interradial is almost touching the angle of the basal plates; second radials more or less quadrangular, wider than high; the third radials giving off two or three secondary radials, of the form of arm plates, of which each one supports an arm. Pinnules strong, less closely arranged than usually in this family, their joints rounded, two or three times as long as wide.

Interradial areæ composed of but few plates, the first one large, placed between the second radials, and leaning partly against the third, with two small plates above. Posterior or anal area wider, the first plate in line with the first radials and of the same size; it is followed by three plates in the second series and several smaller ones above, the upper ones connecting with the vault. Vault, and form of the anus unknown.

Geological Position, etc.—The only three known species are Upper Silurian, from the age of the Niagara group.

1839. **Dimerocrinus decadactylus** Phillips. Type of the genus. Murchison's Silur. Syst., p. 674, Pl. 17, fig. 4; d'Orbigny, 1850, Prodr. de Paleont., i, p. 46; Pictét, Traité de Paleont., i, p. 368. Upper Silurian. Dudley, Eng.

*1852. **Dimerocr. liliiformis** Hall. (**Thysanocr. liliiformis**) Paleont. N. Y., ii, p. 188, Pl. 42, figs. 1 a-f. Niagara gr. Lockport, New York.

*1852. **Dimerocr. immaturus** Hall. (**Thysanocr. immaturus**) Paleont. N. Y., ii, p. 191, Pl. 42, figs. 4 a-f. Niagara gr. Lockport, N. Y.

6. LAMPTEROCRINUS Roemer.

1860. Roemer. Silur. Fauna West. Tenn., p. 37.
1863. Hall. Trans. Albany Inst., iv, p. 202.
1868. Hall. 20th Rep., N. Y. St. Cab. Nat. Hist., p. 328.
Syn. *Balanocrinus* Troost, 1850 (not Agassiz, 1846), Cat. Foss. Tenn.

Hall, in comparing the genera *Glyptocrinus*, *Glyptaster*, *Balanocrinus* and *Lampterocrinus* (Trans. Albany Inst., iv, p. 202), considered the last two identical, and that they differ from the former in having larger underbasals. He then discriminated in favor of Troost's Catalogue name, but afterwards in the 20th Rep. N. Y. St. Cab., p. 320, he very properly, recognized the priority of Roemer's name *Lampterocrinus.* A difference as above stated would scarcely be sufficient to warrant a generic separation, but we think this genus is separable from the other two by other and more important characters than those noted by Hall. *Lampterocrinus* differs from *Glyptocrinus* in the arrangement of its anal plates, and in having an anal tube; from *Glyptaster* in the anal and arm structure, and from both of them in the size of the basals and underbasals, in the form and construction of the vault, and in the pentagonal column.

Roemer describes *Lampterocrinus* as having four primary radials, the fourth bifurcating and excavated for the reception of an arm. This is not quite in accordance with our views, we think the so-called fourth radial is an arm-bearing secondary radial, which is given off in a similar manner as is the plate which supports the first arm in *Steganocrinus sculptus* (Pl. 18, fig. 3); this explains sufficiently the form of the third radials, which are here truncate above instead of axillary as usually. The arms are unknown, but we judge from the enormous size of the so-called arm openings, which form large breaks, that the body in this genus was extended into lateral appendages, and gave off numerous arms.

Generic Diagnosis.—Body oblong, contracted between the arm bases, except the posterior side, which toward the dome bulges considerably, thereby producing some irregularity in the general form. Calyx, cup- or urn-shaped, beautifully ornamented with radiating striæ.

Underbasals five, forming a pentagon, the plates of equal size, quadrangular, the sides of the outer angles shorter. Basals five, large, sometimes fully as large as the first radials, four of them equal and angular above, the posterior one considerably higher and its upper side truncate. Primary radials 3(?) × 5, wider than high, all three hexagonal and with truncate upper side, decreasing in size upward; the third not more than one-fourth the size of the first. Higher orders of radials unknown, but probably formed into free rays which give off arms laterally.

The interradial plates extend uninterruptedly into the vault, those of the calyx and vault being undistinguishable; indeed, in this genus it almost appears as if the interradial pieces of the calyx extend up to the proximal vault pieces. The first interradial rests slightly between the upper sloping sides of the first and between the second radials, with a number of series above, composed of two or three plates each. The first anal plate rests directly upon the posterior basal, which is of such great height that the upper side of the anal is horizontally in line with the top of the first interradial. There are three plates in the second and all succeeding series, arranged longitudinally, forming three rows, of which the plates of the median one are wider and marked by an elevated ridge.

Form of the vault unsymmetrical, bulging at the posterior side, with a subcentral anal tube; plates rather large and nodose, the radial ones decreasing in size toward the arms.

The apical dome plates, although not distinguished by size, are readily recognized by their position. Length of anal tube unknown.

Column pentagonal, central canal very small.

Geological Position, etc.—*Lampterocrinus* is only known from the Niagara group of America.

1861. **Lampterocrinus inflatus** Hall. (**Balanocr. inflatus**) Geol. Rep. Wis. (Rep. of Progress), p. 22; **Lampterocr. inflatus**, 1868, 20th Rep. N. Y. St. Cab. Nat. Hist., p. 328, Pl. 10, fig. 6. Niagara gr. Racine, Wisconsin.

This species is described from internal casts, but there can be no doubt as to its generic identity; the specific characters, however, are undeterminable.

1860. **Lampterocr. Tennesseensis** Roemer. Type of the genus. Silur. Fauna West. Tenn., p. 37, Pl. 4, figs. 1 a, b. Niagara gr. Western Tennessee.

Syn. **Balanocr. sculptus** Troost, 1850. Catalogue name.

7. SAGENOCRINUS Angelin.

1843. Austin. Ann. and Mag. Nat. Hist. (ser. i), xi, p. 205.
1857. Pictét. Traité de Paléont., iv, p. 323.
1878. Angelin. Iconogr. Crin. Suec., p. 8.
1879. Zittel. Handb. d. Palæont., i, p. 375.

Syn. *Rhodocrinus* (in part) Miller, 1821; *Actinocrinus* (in part) Phillips, 1839; Salter, 1859, *Glyptocrinus* d'Orbigny (not Hall), 1850, Prodr., i, p. 46.

Syn. *Megistocrinus* Angelin (not Owen and Shumard), 1878, Iconogr. Crin. Suec., p. 8.

The genus *Sagenocrinus* was based upon a species from Dudley, England, which had been referred by Miller to his *Rhodocr. verus*, and which he believed to occur both in the Subcarboniferous and the Upper Silurian. The Subcarboniferous specimens are now conceded to be distinct, constituting the type of *Rhodocrinus*, and they have in contrast to the Silurian forms the arms constructed of double joints. The Silurian species, with three underbasals and single arm joints, was separated by Phillips as *Actinocr. expansus*, and in 1843 was made by Austin the type of *Sagenocrinus*. Miller's figure $\frac{1}{A}$, p. 106, is evidently ideal, made up from the arms of *Sagenocr. expansus*, and the body of *Rhodocr. verus*. The body in the former has perfectly smooth plates, and the latter has certainly not single-jointed arms, as these do not occur in this family beyond the Silurian. *Sagenocrinus* differs from *Rhodocrinus* in having only three underbasals, in the form of the body, and in the arm structure. It is possible that Wirtgen and Zeiler's *Rhodocr. gonatodes* is a *Sagenocrinus* if not a *Thylacocrinus*. The species is only known from casts.

Austin places *Sagenocrinus* with the Periechocrinidæ, Pictét with the Actinocriniens, Angelin in a family by itself, which he arranges systematically next to the Taxocrinidæ. It cannot be denied that *Sagenocr expansus*, in its general structure, and particularly in the arms, resembles some species of *Taxocrinus*, but the body lacks entirely the articulate structure. Zittel places it in a subdivision of the Glyptocrinidæ.

Generic Diagnosis.—General form including arms, oblong. Calyx cyathiform; without ridges along the radial regions, and without marked surface ornamentation; symmetry slightly bilateral.

Underbasals three, unequal, anchylosed, forming a pentagon. Basals five,[1] differing somewhat in form, generally four of them acute above, the fifth truncate. Primary radials 3 × 5, of nearly equal size, the first and third of a like form, but reversed. Secondary radials 4 × 10, rather large, their upper and lower sides parallel. The upper plate bifurcating, giving off from each side a primary arm—making twenty in all—which at intervals divide again. The branches are toward the inner side of the ray, and remain simple throughout. The arms taper rapidly near the ends, and—if the fragment figured by Angelin, Iconogr., Pl. 28, fig. 8, belongs to this genus, of which we entertain some doubt—the upper parts coil spirally inward once or twice. They are composed of single joints, which are wide and short, quadrangular, with sutures nearly parallel, except the bifurcating plates which are depressed pentagonal. Pinnules short (Angelin).

Interradial spaces not depressed, plates numerous, composed of four or more series of two plates each, very gradually decreasing in size. The first plate rests deeply between the first radials, almost touching the upper angle of the basals. The first anal plate rests upon the truncate side of the posterior basal, supporting two plates in the second, and three in the third series. Interaxillaries one or more.

General form and structure of the vault not known, but it evidently was elevated near the arm regions, and composed of a large number of small plates. Anus unknown.

The column, according to Angelin (Pl. 27, fig. 8), is tripartite (?) and perforated with a large pentalobate canal.

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[1] Angelin gives the number of basals (parabasals) as six, which is evidently a mistake, nor do we believe that the sixth plate represents an anal plate, as no plate of that kind has ever been observed below the line of radials.

1839. **Sagenocrinus expansus** Phillips. (**Actinocr. expansus**) Murchison's Silur. Syst., p. 674, Pl. 17. fig. 9; Austin, 1843, **Sagenocr. expansus** Ann. and Mag. Nat. Hist., xi (ser. i), p. 205; Morris, 1843, Cat. Brit. Foss. (ed. i), p. 58; d'Orbigny, 1850, **Glyptocr. expansus**, Prodr. de Paleont., i, p. 46; Pictét, 1857, **Sagenocr. expansus**, Traité le Paléont., iv, p. 323; Salter, 1859, **Glyptocr. expansus**, Silur. Syst. (ed. ii), p. 512, Pl. 15, figs. 1, 2; Angelin, 1878, Icon. Crin. Suec., p. 8, Pl. 15, figs. 6, 8 and (?) Pl. 27, figs. 8 a, b and (?) Pl. 28, fig. 8. Upper Silur. Dudley, England.

Syn. **Rhodocr. verus** Miller (in part). Nat. Hist. of Crin., p. 106, Pl. 1, fig. 1 a. Dudley, Engl.

c. RHODOCRINITES.

8. LYRIOCRINUS Hall.

1852. Hall. Paleont. New York, ii, p. 197.
1857. Pictét. Traité de Paléont., iv, p. 329.
1866. Shumard. Trans. Acad. Sci. St. Louis, ii, p. 379.
1867. Hall. 20th Rep. N. Y. St. Cab. Nat. Hist., p. 325.
1879. Hall. 28th Rep. N. Y. St. Cab. Nat. Hist. (ed. ii), p. 139.

Syn. *Marsupiocrinites* (not Phill.), Hall 1843. Geol. 4th Distr. New York, p. 114.

Syn. *Rhodocrinus* (not Miller), Hall 1863. Trans. Albany Inst., p. 198.

The genus *Lyriocrinus* was proposed for a species which had been previously described by Hall under *Marsupiocrinites.* It was supposed to possess only one ring of plates beneath the radials, but when afterwards five small underbasals were discovered, it was referred by Shumard (1866) subgenerically under *Rhodocrinus*, and this arrangement was adopted by Hall. *Lyriocrinus* is at least as distinct from *Rhodocrinus* as either *Glyptocrinus* or *Glyptaster*, which those authors acknowledge as genera without question.

In 1863—Trans. Albany Inst., p. 198—Hall described as *Rhodocr. melissa* a new species from Waldron, Ind., which we have always suspected to be closely allied to *Lyriocrinus*, and which, as we have lately ascertained to our satisfaction, belongs to that genus. We are indebted to Wm. F. Gurley, Esq., of Danville, Ill., for the loan of some excellent specimens, which enabled us to examine not only the construction of the arms, but also of the vault which was heretofore imperfectly known.[1]

Pictét places this genus under the Carpocrinidæ, Zittel under

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[1] In the second edition of the 28th Rep. New York St. Cab., which came to hand after this was written; also Hall refers that species but parenthetically to *Lyriocrinus.*

Angelin's Calyptocrinidæ, with which it has some superficial resemblance in the form of the calyx, and in the arrangement of the radial and interradial plates, but from which it is otherwise very distinct. Its closest affinities are with *Ripidocrinus* Beyrich, in which, however, the arms are very differently constructed.

Generic Diagnosis.—Form of calyx depressed, subglobose, or nearly hemispherical; symmetry more or less perfectly equilateral. Plates heavy, their surface flat or sometimes a little concave, smooth, or finely granulose. Vault very low, scarcely rising above the height of the calyx.

Underbasals five, very small, abruptly and deeply depressed, concealed by the column. Basals five, of uniform size, either heptagonal and supporting upon the upper truncate side the first interradial, or four of them hexagonal, angular above, and only the posterior one truncate for the support of the first anal plate. Primary radials 3 × 5, of nearly equal size; the first pentagonal; the second and third hexagonal. The latter is truncate above, and supports within the axil of the secondary radials which are given off from the upper sloping sides of the primary radials, a comparatively large, elongate, hexagonal interaxillary plate, which extends to the height of the first arm joints. Secondary radials 2 × 10, the first large, pentagonal, the second shorter, and supporting the arms.

Interradial plates four to five, in three series; the first large, heptagonal; the two plates of the second series a little smaller than the first, but yet comparatively large; the third series small, composed of one or two plates, which are enclosed by the secondary radials. The anal area is frequently not distinct from the four others, but it has occasionally three plates in the second series. The plates of the lower calyx are of about uniform size, but the last secondary radials, the interaxillary, and the upper series of interradial plates are considerably smaller.

Vault almost flat, composed of a large number of convex plates, which are depressed in the interradial regions. Anus subcentral or excentric, in form of a strong tube, constructed of similar plates as the vault; length unknown. Apical dome plates well defined, twice as large as the other vault pieces. Ambulacral or arm passages directed upward, and passing at the edge through the vault. Arms ten, which remain simple, placed wide apart, strong, gradually tapering to the tips, and constructed, from the radials up, of two series of wide and short interlocking pieces. Arm furrows wide and deep; pinnules present, but their exact form not known.

Column round; central canal small.

Geological Position, etc.—*Lyriocrinus* occurs only in rocks at the age of the Niagara limestone of America.

We recognize only two species; *L. sculptilis* Hall, a third species is described from mere casts, and very doubtful.

1843. **Lyriocrinus dactylus** Hall. (**Marsupiocrinites dactylus**) Type of the genus. Geol. Rep. 4th Distr. N. York, p. 114; Hall, 1852, **Lyriocr. dactylus**, Paleont. N. Y., Pl. 44, figs. 1 a–g; Pictét, 1857, Traité de Paléont., iv, p. 329, Pl. 101, fig. 12. Niagara gr. Lockport, N. York.

1863. **Lyriocr. melissa** Hall. (**Rhodocr. melissa**) Trans. Albany Inst., p. 198; also 28th Rep. N. Y. St. Cab. Nat. Hist. (ed. ii), p. 139, Pl. 15, figs. 18–22. Niagara gr. Waldron, Ind.

9. RIPIDOCRINUS Beyrich.

1879. Zittel. Handb. der Palæont., i, p. 377.
Syn. *Rhodocrinus* Goldfuss. Petrefact. Germ., i, p. 211; Agassiz, 1835, Mem. Soc. Neuchat., i, p. 196; Müller, 1841, Verhandl. d. Berl. Akad., i; Roemer, Verh. Naturh. Verein f. Rheinl., viii, p. 358; and 1855, Lethæa Geogn., ii, p. 241; Pictét, 1857, Traité de Paléont., iv, p. 314; Schultze, 1867, Echin. Eifl. Kalk, p. 53.

Beyrich's name *Ripidocrinus*, so far as we now know, was first published by Zittel to include *Rhodocr. crenatus* Goldf. This species differs very materially in the arm structure from *Rhodocrinus* as established by Miller. In the general form of the body and the arrangement of the plates, it resembles *Lyriocrinus* Hall, but the arm structure separates them widely.

Generic Diagnosis.—Calyx cup- or urn-shaped, sometimes subglobose, lower portions more or less truncate, the basals spread out horizontally from the column; plates heavy, highly ornamented; symmetry equilateral. Body extended into free rays with lateral arms.

Underbasals five, closely anchylosed, small, forming a pentagon, deeply depressed, and generally hidden from view by the large column; central perforation large, pentalobate.

Basals five, equal, irregularly hexagonal, the lower side in line with the sides of the inner pentagon; the lower lateral sides, by which the plates are united, extremely short; upper lateral margins, which enclose the first radials, unusually long; upper side truncate supporting the first interradial, and parallel with the lower one. Owing to this construction, the basals have a subquadrangular outline, and the lower angle of the first radials almost touches the upper angle of the underbasals.

Primary radials 3 × 5, of nearly equal size, the first pentagonal, the second hexagonal, the third again pentagonal, and supporting two secondary radials (2 × 10). The first plate larger than the second, the latter axillary, but the sloping sides not of equal width. The longer side, next to the middle of the ray, supports an indefinite number of radials, and these extend into free appendages; while the other, shorter side, gives off laterally the first arm. There are two of these appendages to each ray, which at the base are connected by one or more interaxillary plates, they are thick, puffy, cylindrical, three or four times as long as the body, decreasing in width upwards. The plates which constitute the outer or dorsal side of the appendages are short, very wide, with parallel sutures, and from them, at certain intervals—from every fourth or fifth plate, and from alternate sides—the true arms arise. The latter are not given off strictly laterally, as the separation from the main trunk actually begins in the median portion of the two or three preceding plates of each order, which show more or less deep oblique incisions. All arms have nearly the same length, and hence do not reach the same general height, those nearer the body are comparatively heavier. The four or five proximal plates of the first arm are laterally connected with the main trunks of the ray, the succeeding arms become detached sooner, and the upper ones are free from their base up. Each arm tapers to a sharp point, is composed of two series of interlocking plates, with closely arranged, sword-like pinnules.

Interradial series composed of six to eight plates; the first large, heptagonal, supported upon the truncate upper side of the basals, between the first radials and the lower sloping side of the second, thus separating the entire radial series; the second range is composed of two somewhat smaller plates, the third of two or three pieces, with one or two plates above. The posterior side is but rarely distinct, it has exceptionally three pieces in the second series.

Vault scarcely rising above the limits of the calyx, slightly elevated in the radial regions. It is constructed of an immense number of small irregularly arranged plates, which decrease in size rapidly toward the periphery. At the edge of the vault there are twenty ambulacral openings, ten of which are larger and connecting with the ten appendages, the ten smaller ones with their first lateral arm. Apical dome plates well developed, much larger than the rest of the plates, and more convex. Anus excentric, in form of a simple opening.

Column heavy, round, sometimes with lateral excrescences; central canal large, pentalobate.

Geological Position, etc.—The only known species of this genus occurs in the Stringocephalenkalk of the Eifel.

1826. **Ripidocrinus crenatus** Goldfuss. (**Rhodocr. crenatus**) Petref. Germ., i, p. 211, Pl. 64, fig. 3; also Agassiz, 1835, Soc. Neuchat., i, p. 196; Roemer, Verh. Naturh. Verein f. Rheinl., viii, p. 358, Pl. 1, fig. 1, and Lethæa Geogn. ii, p. 241, Pl. 4, figs. 17, a-b; Pictét, 1857, Traité de Paléont, iv, p. 314, Pl. 100, fig. 10; Schultze, 1867, Echin. Eifl. Kalk, p. 53, Pl. 7, figs. 1 a-n; Zittel, 1879, Handb. der Palæont, p. 377, fig. 263. Devonian. Eifel, Germ.
Syn. **Rhodocr. tessellatus** Steininger. Geogn. Beschreibung der Eifel, p. 36.

10. THYLACOCRINUS Oehlert.

1878. Oehlert. Extract du Bull. Soc Géol. de France (ser. 3), vii, (November No.).
1879. Zittel. Handb. d. Palæont., i, p. 375.

This genus was placed by Zittel among his Glyptocrinidæ, but it agrees much closer with some species of *Rhodocrinus*, from which it differs in having very much longer, heavier and undivided arms. This difference would perhaps entitle it only to a subgeneric rank, if not the arms in the Rhodocrinidæ generally were short, thin and bifurcating.

Generic Diagnosis.—Body large, globular. Calyx inflated at the lower part, somewhat constricted toward the arm regions; plates thin, convex, without special ornamentation; symmetry almost equilateral.

Underbasals five, small, forming a pentagonal disk. Basals five, hexagonal, upper and lower sides parallel, the lower resting against the straight sides of the inner pentagon, the upper supporting the first interradials. Primary radials 3 × 5; the first hexagonal; the second larger than the first; the third supporting 2 × 10 secondary radials, and these in turn the arms.

Arms heavy, extremely long, five or six times the height of the calyx, simple throughout. The proximal joints are single, quadrangular, but they change directly into wedge-form, and gradually into a double series of interlocking pieces. Pinnules closely arranged.

Interradials numerous, the lower one resting upon the basals. There are from ten to twelve in the typical species, with a few additional plates at the anal side.

Dome elevated, composed of a large number of small pieces. Anus and column unknown.

The only known species is :—

Thylacocrinus Oehlert. Extr. du Bull. Soc. Géol. de France (ser. 3), vii, Pl. 1, fig. 1.
Devon. St. Germain, France.

11. **ANTHEMOCRINUS** nov. gen.

(*ἄνϑεμον*, a blossom ; *κρῖνον*, a lily).

Syn. *Eucrinus* Angelin. (in part). Iconogr. Crin. Suec.

Among the species described by Angelin under *Eucrinus*, there are two which differ materially from the rest in having only two primary radials, a single interradial, and this plate resting directly upon the basals; also in the arm structure. These characters, in our opinion, are sufficient to justify the removal of the species from *Eucrinus*, and we propose to establish for them the genus *Anthemocrinus*, with Angelin's *Eucr. venustus* = *Anthemocrinus venustus* as type.

Generic Diagnosis.—Calyx depressed, subglobose, composed of comparatively few plates, which in both known specimens are convex and striated.

Underbasals five (Angelin), small. Basals five, large, subequal, hexagonal, the upper side truncated for the support of an interradial plate. Primary radials 2 × 5, both pentagonal, wider than high, of nearly equal size and similar form; the first and second meeting by straight margins. The second plate supports upon each sloping side a single secondary radial, which in turn supports a heavy arm, this soon divides, sometimes a second time, and the branches after each division are half as large as the arm below. All the arms and branches, from the base up, are composed of two rows of joints, alternately arranged, very slightly interlocking. The first arm joints are enclosed within the body walls by one or two interbrachial plates. The branching of the arms and the whole arm structure is very similar to that of *Periechocrinus*.

There is properly only a single plate in each interradial area, and this, as stated, rests upon the truncate upper side of the basals between both primary radials, and extends to the arm bases. It is the largest plate of the entire calyx, hexagonal, higher than wide, and supports upon its upper side—between the arms—the interbrachial plates above mentioned. The anal area, if we interpret Angelin's figure correctly, differs in having above its first plate a row of smaller plates, longitudinally arranged as in *Glyptaster* and *Eucrinus*, and these support the anus.

Vault and anal aperture unknown. Column round.

Geological Position, *etc.*—The two known species are from the Upper Silurian of Sweden.

* **Anthemocrinus minor** Angelin. (**Eucr. minor**) Icon. Crin. Suec., p. 25, Pl. 15, fig. 5, Upper Silurian. Gothland, Sweden.

* **Anthemocr. venustus** Angelin. Type of the genus (**Eucr. venustus**). Icon. Crin. Suec., p. 25, Pl. 15, figs. 7, 16. Upper Silurian. Gothland, Sweden.

12. RHODOCRINUS Miller.

1821. Miller. Natur. Hist. of the Crinoidea, p. 106.
1835. Agassiz. Mem. Soc. Sci., Neuchat., i, p. 196.
1841. Müller. Monatsb. Berl. Akad., i, p. 209.
1843. Austin. Ann. and Mag. Nat. Hist., x, p. 109.
1850. D'Orbigny. Prodr. de Paléont, i, p. 104.
1853. De Koninck and Lehon. Recher. Crin. Carb. Belg., p. 103.
1855. Roemer. Lethæa Geogn. (Ausg. 3), p. 240.
1855. Wirtgen and Zeiler. Verh. Naturh. Verein f. Rheinl., xii, p. 11.
1858. Hall. Geol. Rep. Iowa, i, pt. ii, p. 556.
1861. Hall. Bost. Journ. Nat. Hist., p. 322.
1879. Zittel. Handb. der Palæont, i, p. 376

(Not *Rhodocrinus* Goldf. 1826, Petref. Germ. i, p. 212; nor Billings, 1859, Geol. Rep. Canada, Decade iv, p. 61; nor Schultze, 1867, Echin, Eifl. Kalk, p. 53; nor Roemer, 1851, Verh. Naturh. Verein f. Rheinl., viii, p. 358).

Syn. *Acanthocrinus* F. Roemer. 1850, Neues Jahrb. f. Mineralogie p. 79; Müller (Wirtgen and Zeiler) 1855, Verh. Naturh. Verein, xii, p. 8; Pictét, 1857, Traité de Paléont, iv, p. 100, Hall, 1862, (subgenus of *Rhodocrinus*) 15th Rep. N. Y. St. Cab. Nat. Hist., p. 125.

Rhodocrinus verus, according to Miller, occurs in both the Mountain limestone and in the Upper Silurian, and it was said to have three basal plates. As we have before shown, Miller confounded two very different species, which have since been recognized as distinct genera. The Silurian form, with three underbasals and single arm joints, is now known as *Sagenocr· expansus;* the Carboniferous form, which took Miller's specific name, is universally regarded as the type of *Rhodocrinus*, having five underbasals instead of three, and the arms composed of two rows of interlocking plates.

Before the true number of underbasals in *Rhodocrinus* was ascertained, Phillips, in 1836 proposed for some allied species, in which he discovered five proximal plates, the genus *Gilbertsocrinus*, but these species for other reasons have since been referred to *Ollacrinus*, which was proposed by Cumberland in 1826. *Rhodocr. crenatus* Goldfuss has been referred to *Ripidocrinus*, and *Rhodocr. quinquelobus* Schultze to *Eucrinus.*

The genus *Rhodocrinus*, as now restricted, is decidedly Subcarboniferous. The few Devonian species which we are unable to separate from it bear more or less resemblance to *Acanthocrinus* Roemer, and have been partly referred to that genus by other writers. We have examined with great care the figures of *Acanthocr. longispinus* from Niederlahnstein as given by Wirtgen and Zeiler, and some excellent specimens of our own, but have failed to discover any characters by which this form may be separated even subgenerically. The spinous projections on the apical plates (basals and first radials) are also found in some of the Subcarboniferous species in all degrees of variation, and are more or less the rule in *Ollacrinus.* It is even not improbable that Roemer's imperfect type specimen *A. longispinus*, which was said to be from the Subcarboniferous, is really an *Ollacrinus*, and generically distinct from the Devonian specimens which Wirtgen and Zeiler identified with that species.

The two Austins placed *Rhodocrinus* under the Actinocrinidæ, D'Orbigny and Pictét under the Cyathocrinidæ, Roemer and Zittel made it the type of a family.

Generic Diagnosis.—Body subglobose to semi-ovate, often wider than high, with a concavity at the base, which frequently includes not only basals but partly the first radial plates. Calyx constricted toward the arm bases, its symmetry almost perfectly equilateral; surface of plates from entirely smooth to convex and nodose, or striated with regular nodes or spines on basal, first radial, and first interradial plates.

Underbasals five, small, spreading horizontally, and hidden by the column, though sometimes slightly visible beyond its periphery. Basals five, equal, comparatively large, heptagonal, upper side truncate. Primary radials 3 × 4, generally as high as wide, decreasing in size upward, the series separated laterally by interradial plates; the first heptagonal; the second from quadrangular to hexagonal, according to the size of the first radials; the third irregular in form. The latter, in the more depressed Subcarboniferous forms, supports only from one to two secondary radials; in Devonian species, there are sometimes three. None of the plates project outward, the upper one, which is also the arm-bearing plate, is excavated at its upper edge, and this, together with a similar excavation in the corresponding dome plates, forms an oblong ambulacral passage, two to each ray, which are separated by an interbrachial plate. The arms of the different rays are widely separated; they are long, delicate, cylindrical, branching, and constructed of two rows of alternate plates, which interlock from the base up. Pinnules small.

Interradial and anal areæ very wide and closely similar, the latter having sometimes one or two additional plates without disturbing the general symmetry of the body. The first plates, which are large, rest upon the truncate upper side of the basals, and laterally between the first radials; the second and third series consists of from two to three plates each, and the plates are of comparatively large size, those of the succeeding series much smaller, and passing gradually into vault pieces.

Vault flat, compressed and narrow, owing to the constriction at the upper part of the calyx; composed of a large number of irregular pieces, among which the apical dome plates are not easily distinguished; radial portions generally protuberant. Anus excentric, protruding like a proboscis, and consisting of almost microscopic plates, possibly capable of expansion or contraction by the animal.

Column round, and composed near the body of very uneven plates; perforation small, pentagonal.

Geological Position, etc.—The genus *Rhodocrinus* ranges from the Devonian to the middle portion of the Subcarboniferous, both in America and Europe.

We recognize the following species:—

1844. **Rhodocrinus abnormis** McCoy. Carb. Foss. Ireland, p. 180, Pl. 26, fig. 3. Mount. limest. Ireland.

1861. **Rhodocr. Barrisi** Hall. Desc. New Sp. Crin., p. 9; also Bost. Journ. Nat. Hist., p. 322, Pl. 6, figs. 16, 17. Upper Burlington limest. Burlington, Iowa.

Syn. **Rhodocr. Barrisi** var. **divergens** Hall, 1861. Desc. New Sp. Crin., p. 9; also Bost. Journ. Nat. Hist., p. 324, Pl. 6, fig. 18.

A comparison with the type specimen and with others in our cabinet, proves beyond doubt that the original **R. Barrisi** was described from a very young specimen, and this explains fully the additional bifurcation in the variety or older specimen.

1836. **Rhodocr. globosus** Phillips. (**Actinocr. globosus**) Geol. Yorkshire, p. 206, Pl. 4, figs. 26, 29. Mount. limest. Yorkshire, Engl.

1855. (?) **Rhodocr. gonatodes** Wirtgen and Zeiler. Verh. Naturh. Verein Jahrg., xii, p. 12, Pl. 3, fig. 3, and Pl. 4, figs. 1, 2, and Pl. 5, fig. 3; Müller, Ibid., pp. 22, 23, 25, Pl. x, fig. 1. Grauwacke. Niederlahnstein, Germ.

This species is only known from casts, and may possibly belong to some other allied genus.

1862. **Rhodocr. gracilis** Hall. (**Rhodocr.—Acanthocr.—gracilis**) 15th Rep. N. Y. Cab. Nat. Hist., p. 127. Hamilton gr. Ontario Co., N. Y.

1861. (?) **Rhodocr. Halli** Lyon. Proc. Acad. Nat. Sci. Phila., p. 412, Pl. 4, figs. 5 a, b. Niagara gr. Near Louisville, Ky.

This species is certainly not **Rhodocrinus,** but the type specimen is too imperfect for accurate diagnosis.

1850. (?) **Rhodocr. longispina** A. Roemer. (**Acanthocr. longispina**) Neues Jahrb. der Mineralogie, p. 679, Pl. 4^{b}; Wirtgen and Zeiler, 1855, Jahrb. Naturh. Verein., xii, p. 8, Pl. 2, figs. 1, 2, and Pl. 3, fig. 1; also Pictêt, 1857, Traité de Paléont., iv, p. 314, Pl. 100, fig. 11. Posidomyen Schiefer, Harz. (Roemer). Grauwacke, near Coblenz (Wirtgen and Zeiler).

1866. **Rhodocr. nanus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 254; also, 1868, Geol. Rep. Ill., iii, p. 476, Pl. 18, figs. 2, a, b. Lower Burlington limest. Burlington, Iowa.

1862, **Rhodocr. nodulosus** Hall. (**Acanthocr. nodulosus**) 15th Rep. N. Y. St. Cab. Nat. Hist., p. 126, Pl. 1, fig. 8. Hamilton gr. Ontario Co., N. York.

1862. **Rhodocr. spinosus** Hall. 15th Rep. N. Y. St. Cab. Nat. Hist., p. 127, Photog. Pls., 1875, Pl. 1, fig. 10. Hamilton gr. Ontario Co., N. Y.

1853. **Rhodocr. stellaris** de Kon. and Leh. Recher. Crin. Carb. Belg., p. 109, Pl. 1, figs. 14 a, b, c (figured by Cumberland, 1819, as Encrinus). Mount. limest. Bristol, Engl., and Tournay, Belg.

1853. **Rhodocr. uniarticulatus** de Kon. and Leh. Recher. Crin. Carb. Belg., p. 107, Pl. 1, figs. 13 a, b, c. Mount. limestone. Visé, Belg.

1860. **Rhodocr. Varsoviensis** Hall. Supp. Geol. Rep. Iowa, p. 80. Warsaw limest. Warsaw, Ill.

1821. **Rhodocr. verus** Miller. Type of the genus. Nat. Hist. of Crin., p. 107, with figures; Agassiz, 1835, Mem. Soc. Sci. Neuchat., i, p. 196; Roemer, 1855, Lethæa Geogn. (Ausg. 3), p. 241, Pl. 4, figs. 2 a-e; Bronn, Ibid. (Ausg. 1, 2). Mount. limest. Near Bristol, Eng.

1879. **Rhodocr. vesperalis** White. Proc. U. S. National Museum, p. 252, Pl. 1, figs. 11, 12. Upper Coal Measures? 30 miles west of Humbolt, Kans.

We doubt if this fossil came from the coal measures, neither *Actinocrinus* nor *Rhodocrinus* have ever been found to occur later than the age of the Warsaw limestone.

1861. **Rhodocr. Wachsmuthi** Hall. Desc. New Sp. Crin., p. 18. Lower Burlington limest. Burlington, Iowa.

1861. **Rhodocr. Whitei** Hall. Desc. New Sp. Crin., p. 9; Bost. Journ. Nat. Hist., p. 324, Phot. Plates, 1875, Pl. 6, figs. 19, 20, 21.

Var. **burlingtonensis** Hall. Desc. New Pal. Crin., 1861, p. 9; also Bost. Journ. Nat. Hist., p. 325. Lower Burlington limestone. Burlington, Iowa.

1858. **Rhodocr. Wortheni** Hall. Geol. Rep. Iowa, i, pt. ii, p. 556, Pl. 9, figs. 8 a, b, c. Lower Burlington limest. Burlington, Iowa.

13. OLLACRINUS Cumberland.

(Pl. 18, fig. 2, and Pl. 19, fig. 1.)

1826. Cumberland. Appendix to Reliquiæ Conservata.
1877. Wachsmuth. Amer. Journ. Sci. and Arts, xiv, p. 125.
1879. Wachsmuth and Springer. Proc. Acad. Nat. Sci. Phila., p. 261.
1879. Zittel. Handb. der Palæont, i, p. 375.

Syn. *Gilbertsocrinus* Phill. Geol. Yorkshire, pt. ii, p. 207; d'Orbigny, 1850, Prodr. de Paléont., i, p. 155; Meek and Worth., 1866, Geol. Rep. Ill. ii, p. 217.

Syn. *Goniasteroidocrinus* Lyon and Casseday. Amer. Journ. Sci. and Arts, vol. 28 (ser. 2), p. 233; Meek and Worthen, 1869 (Subgenus of *Gilbertsocrinus*), Proc. Acad. Nat. Sci. Phila., p. 75 and 1873, Geol. Rep. Ill., v, p. 389.

Syn. *Trematocrinus* Hall. Supp. Geol. Rep. Iowa, p. 70; Meek and Worthen, 1860, Proc. Acad. Nat. Sci. Phila., p. 383.

Syn. *Rhodocrinus* (in part) de Koninck and Lehon. Recher. Crin. Carb. Belg., p. 104.

The form under consideration was first made known by Cumberland in the Appendix to his Reliquiæ Conservata, 1826, under the name *Ollacrinus*. He published no generic diagnosis nor specific name, but gave excellent figures, by which the type represented can be easily identified. It is characterized by a pentamerous figure, concave base, flat vault, excentric anal opening, spiniferous first radials, and by large oval-shaped interradial and anal spaces, with numerous plates. There are two sets of openings in the brachial regions, the largest supported by the secondary radials, and the others located nearly above them, being smaller, and perforated directly through the centre of pairs of plates in the margin of the vault.

In 1836, Phillips, in the Geology of Yorkshire, proposed the genus *Gilbertsocrinus*, and included in it Cumberland's type, which he described as *G. calcaratus*, and two other species. His figures are fairly good, but his descriptions are very meagre, and show no essential difference from *Rhodocrinus*. They contain no allusion to the two sets of openings,[1] so prominent in his figures, but he apparently considers the upper openings as belonging to " rounded arms, perforated in the centre."

De Koninck and Lehon, in 1854, declared that both *Ollacrinus* and *Gilbertsocrinus* were synonyms of *Rhodocrinus* and ought to be suppressed.

In 1859, Lyon and Casseday described a new species of this type from the upper Subcarboniferous rocks of Kentucky, and proposed for its reception the genus *Goniasteroidocrinus*, which is in every essential respect similar to the forms figured by Cumberland and Phillips, with the exception perhaps, that the upper sets of supposed arm openings, instead of being located directly above the ray, as seems to be the case in some of the British specimens, as figured, are situated " midway between the primary radials " or interradially. Their species—the well-known *G. tuberosus*—was found in excellent preservation, with all the appendages attached, and a good figure of it may be seen in the Geol. Rep. Ill., ii, p. 220. Lyon and Casseday took the upper and larger appendages to be arms, five in number, and below and between these, in the " interradial fields," as they say, they found clusters of from five to seven " long, pendulous cilia," bearing delicate pinnules. These " cilia " they afterwards refer with a query to arms.

A year later, Hall, without any reference to the above descriptions, described under the new generic name *Trematocrinus* a number of species from the Subcarboniferous of the West, of undoubted generic identity with Lyon's species. He, too, considered the interradial appendages to be arms, though he doubted if they could have performed the functions of ordinary arms, and the foramina above the secondary radials he supposed to be openings for fleshy arms or tentacles, not having seen in his specimens any indications of solid arms or even articulating plates. Soon afterwards, however, Hall described from the Devonian of New York his *Trematocr. spinigerus* (15th Rep. N. Y. St. Cab., p. 128), which has the interradial appendages from the vault, and also long arms like *Rhodocrinus* from the radial or ambulacral openings. He called the former " summit arms," and the latter " true arms."

In the second volume of the Ill. Geol. Rep., Meek and Worthen gave an excellent description of the genus, and showed that the arms in this type proceed from the radial openings as in other crinoids, and that the interradial appendages are not arms at all. They state that the true arms are always pendant, apparently overlooking Hall's *T. spinigerus*, but this is not uniformly the case even in the Carboniferous species, as we afterwards discovered in Hall's *T. tuberculosus*, (see Proc. Phila. Acad. Nat. Sci., 1878, p. 262), whose arms stand erect, and fold over the dome. We also found the ventral furrow of the arms to be always on the inner side of the arm, next to the body, and accordingly on reverse sides in the erect and the pendant arms. It is possible that this feature may warrant a subdivision of the genus, but until we are better acquainted with the arms in the majority of the species we shall not attempt it.

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[1] Attention was first called to these by Billings, Decade iii, Geol. Surv. Can.

Meek and Worthen proposed to arrange the British and American species under two sections, based upon the different positions of the so-called false arms, whether placed above the interradial regions as in the latter, or more radial as in the former. We do not attach much importance to this variation, especially in view of our interpretations of the relations and functions of these appendages, besides there is considerable variation in this respect among the American species. The arm openings are in some cases located well under the overhanging margins of the bases of the false arms, in others on either side of them. In no case, however, among American specimens have the false arms been observed to be directly over the ray, as represented in Phillips' diagram of *G. bursa*, and we are by no means satisfied that such was actually the case in the British species, for sometimes the basals alone are prominent and spiniferous, sometimes only the first radials, and it is possible that in some cases they have been confounded.

Some authors, notably Meek and Worthen, object to Cumberland's name *Ollacrinus* because it was not accompanied by any diagnosis or specific name, and give precedence to *Gilbertsocrinus*, the generic and specific descriptions of which disclose no characters to distinguish the genus from *Rhodocrinus*, and which, moreover, entirely overlooked the real characteristic features of this type. Cumberland's published figures give a distinct exposition of essential characters, which leave no room for doubt as to the type represented, and under the rules adopted by the British Association relative to descriptions by the earlier writers, this entitles the name *Ollacrinus* to priority, which leaves *Gilbertsocrinus*, *Goniasteroidocrinus* and *Trematocrinus* as synonyms.

The nearest affinities of this genus are with *Rhodocrinus*, with which it substantially agrees in the structure of the body below the arms, but from which it is conspicuously distinguished by the pseudo-brachial appendages, as well as the size and disposition of the true arms. The two genera are, however, connected through the transition form *O. spinigerus* Hall, which has the arms and body similar to many species of *Rhodocrinus*, yet the pseudo-brachial appendages of *Ollacrinus*.

These appendages are an extraordinary and most characteristic feature of the genus, and no trace of any similar structure has been observed in any other crinoid. The precise office of these organs has puzzled all writers hitherto, and must yet remain to some extent a matter of conjecture. Each of the five main trunks contain two longitudinal perforations running a little to either side of the centre, and one of these passes into each of the rounded branches into which the trunk divides, and pierces its centre to the extremity. They have no other opening, and no external furrows of any kind, but are simply ten thickened cylindrical tubes, which join in pairs by their outer walls near the body, where the two together have a transversely flattened elliptic outline. The passages penetrate the body independently, near—and usually somewhat above—the arm openings, though sometimes directly between the openings of the arms of two different rays. Inside the walls they unite with the arm furrows, in a similar manner as the lateral pore passages in *Batocrinus*, and in view of all the facts, we entertain no doubt, that these openings are of the same nature as those which we have called respiratory pores in the Actinocrinidæ and Platycrinidæ, and which instead of being simple openings, with probably soft parts attached, are here extended into tubes forming a part of the calcareous test. There are five pairs of these elongated pores, and it makes no material difference whether they enter the body a little more radially or interradially, they are placed near the arm bases, and soon connect with the arm passages within the body, as the respiratory pores in *Batocrinus*. In many species there are deep depressions in the vault, opposite the base of each appendage, which are paved with a great number of small irregular polygonal plates. It is not at all improbable that these areæ were susceptible of a certain amount of contraction and expansion, and that they performed an important function in connection with the tubular extensions, in the introduction and expulsion of water.

Generic Diagnosis.—Body generally large, subglobose, about equilaterally pentamerous; plates of the calyx convex to nodose or spiniferous; base concave, vault flat, its margins extended into five free tubular appendages, situated between, or partly above the rays.

Underbasals five, small, pentagonal, forming a flat impressed pentagon, entirely involved in the basal concavity, and sometimes hidden by the column. Basals five, hexagonal or obtusely heptagonal, truncate above, and like the first radials often produced into sharp spines, which extend obliquely downward Primary radials 3 X 5, the first larger than the rest, heptagonal, the second hexagonal, the third hexagonal or heptagonal and supporting on its upper sloping sides the secondary radials, in two series of two to three plates each, which diverge rapidly, arching over the interradial spaces, and completely separating them from the vault. The last secondary radial supports the small delicate arms, its inner sloping side being indented by the arm opening, while its outer side bears an additional plate, which meets with a similar plate of the adjoining ray, and the two together form the base of a false arm.

Interradial and anal areæ scarcely distinguishable from each other; large, oval, sometimes slightly depressed. They are occupied by from ten to eighteen pieces, of which there is one large hexagonal plate in the first range, resting on the truncate upper side of the basals, and between two first radials. This is succeeded by from three to five ranges, the second, third and fourth consisting of three—rarely four—plates, and those above of two and one plate. Interaxillary plates two to eight or ten, the upper ones connecting with the vault and the false arms.

Arms four to nine to the ray, according to the species, the number of primary arms being perhaps restricted to four, the additional ones being produced by branching very close to the body. They are slender and delicate, composed of a double series of interlocking plates, and they bear minute pinnules

The arm openings are situated in rather large, deep depressions, lying under the edges of the pseudo-brachial appendages, but only when the latter are very large, on either side of them when they are small. In the latter case, so far as observed, the arms are erect and folded over the dome, in the former pendant, but in either case the ambulacral furrow lies to the inner or under side of the arms, close to the body, showing the pendant position to be the normal one.

Vault depressed, generally flat, composed of numerous, somewhat convex, polygonal plates, among which the apical and radial dome plates may be readily distinguished by their greater size. The interradial regions are occupied by a large number of small pieces, which are generally found more or less depressed just in front of the base of each false arm. The structure is such that these parts may have been flexible and capable of contraction or expansion. Anal opening directly through the vault, not protruding, situated about midway between the centre and the margin.

The margin of the dome above, and generally between the arm bases of different rays, is extended into five pseudo-brachial appendages, which near the body are comparatively heavy, nearly solid, transversely elliptic, composed of two rows of semi-elliptical joints, rounded on the outside, and joining in the middle by straight, vertical faces. At from four to eight joints from the body, each trunk divides into two rounded branches tapering to a point, which are perforated throughout their length by a small central passage, these passages enter the body in pairs through the main appendages, and thence diverge toward the arm furrows, with which they unite. There are no other openings, nor any external furrows, these organs being simply heavy calcareous tubes, with a jointed structure like that of the column.

Column round, composed of joints alternately larger and smaller; central perforation of medium size, pentagonal.

Geological Position, etc.—*Ollacrinus* is essentially a Subcarboniferous genus, all the known species being from rocks of that age, except a single species which is from the Hamilton group of New York, and this is a transition form. It occurs both in Europe and America.

We recognize the following species :—

*1836. **Ollacrinus bursa** Phill. (**Gilbertsocr. bursa**) Geol. Yorkshire, p. 207, Pl. 4, figs. 24, 25; Austin, 1842, **Rhodocr. bursa**, Ann. and Mag. Nat. Hist., p. 109; also d'Orbigny, **Gilbertsocr. bursa**, Prodr. de Paléont., i, p. 155. Mount. limest, England.

*1836. **Ollacr. calcaratus** Phill. (**Gilbertsocr. calcaratus**) Geol. Yorkshire p. 207, Pl. 4, fig. 22; d'Orbigny, 1850, Prodr. de Paléont., i, p. 155; Austin, 1842, **Rhodocr. calcaratus**, Ann. and Mag. Nat. Hist., p. 109. Mount. limest. England. (Cumberland's original figure in the Reliquiæ Conservata, 1826, represents this species.)

*1860. **Ollacr. fiscellus** Meek and Worth. (**Trematocr. fiscellus**) Proc. Acad. Nat. Sci. Phila., p. 383; also 1865, **Gilbertsocr.** (**Goniasteroidocr.**) **fiscellus**, Ibid., p. 167; also 1866, **Gilbertsocr. fiscellus**, Geol. Rep. Ill., ii, p. 222, Pl. 15, fig. 5. Lower Burlington limest. Burlington, Iowa.

*1836. **Ollacr. mammilaris** Phill. (**Gilbertsocr. mammilaris**) Geol. Yorkshire, p. 207, Pl. 4, fig. 23; also d'Orbigny, 1850, Prodr. de Paléont., i, p. 155; Austin, 1842, **Rhodocr. mammilaris**, Ann. and Mag. Nat. Hist., p. 109. Mount. limest. England.

1869. **Ollacr. obovatus** Meek and Worth. (**Goniasteroidocr. obovatus**) Proc. Acad. Nat. Sci. Phila., p. 76; Geol. Rep. Ill., v, p. 391, Pl. 4, fig. 6; Wachsm. and Spr., 1878, **Ollacr. obovatus**, Proc. Acad. Nat. Sci. Phila., p. 263. Uppermost part of Upper Burlington limest. Burlington, Iowa.

*1860. **Ollacr. reticulatus** Hall. (**Trematocr. reticulatus**) Desc. New Sp. Crin., p. 9; also Bost. Journ. Nat. Hist., p. 325. Lower Burlington limest. Burlington, Iowa.

*1860. **Ollacr. robustus** Hall. (**Trematocr. robustus**) Supp. Geol. Rep. Iowa., p. 77. Lower part of Keokuk limest. Nauvoo, Ill., and Keokuk, Iowa.

1843. (?) **O. simplex** Portlock. (**Gilbertsocr. simplex**) Geol. Londonderry, p. 350, Pl. 16, figs. 3 and 13. Fermanaugh, Ireland. Mount. limestone. (This species may possibly belong to **Rhodocrinus**, variety **Acanthocrinus**; the upper portions of the body are not known.)

*1862. **Ollacr. spinigerus** Hall. (**Trematocr. spinigerus**) 15th Rep. N. Y. St. Cab. Nat. Hist., p. 128. Hamilton gr, Devonian. Ontario Co., N. Y.

*1869. **Ollacr. tenuiradiatus** Meek and Worth. (**Goniasteroidocr. tenuiradiatus**) Proc. Acad. Nat. Sci. Phila., p. 75; Geol. Rep. Ill., v, p. 389, Pl. 11, fig. 1. Lower Burl. limest. Burlington, Iowa.

1860. **Ollacr. tuberculosus** Hall. (**Trematocr. tuberculosus**) Supp. Geol. Rep. Iowa, p. 75; Wachsm. and Spr., 1878. **Ollacr. tuberculosus** Proc. Acad. Nat. Sci. Phila., p. 263. Upper Burlington limest. Burlington, Iowa.

Syn **Trematocr. papillatus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 78. Synon. (Wachsm. and Spr., 1878).

*1859. **Ollacr. tuberosus** Lyon and Cass. (**Goniasteroidocr. tuberosus,** and type of that genus). Amer. Journ. Sci. and Arts, vol. 28, (ser. 2) p. 233; Wachsm. and Spr., Proc. Acad. Nat. Sci. Phila., p. 263. Keokuk limest. Crawfordville, Ind., and Hardin Co., Ky.

1860. **Ollacr. typus** Hall. (**Trematocr. typus,** type of that genus). Supp. Geol. Rep. Iowa., p. 73; Wachsm. and Spr. **Ollacr. typus.** Proc. Acad. Nat. Sci. Phila., p. 262. Upper Burlington limest. Burlington, Iowa.

Doubtful Genera.

The following genera, which evidently belong to the Sphæroidocrinidæ, are too imperfectly defined to be grouped systematically.

1. (?) **CONDYLOCRINUS** Eichwald.

1860. Eichwald. Lethæa Rossica, i, p. 612.

From Eichwald's description, it is impossible to get a correct understanding of this genus. He describes it as having ten basals, three radials, two rows of plates placed above the radials, and numerous other little plates irregularly arranged; the plates tumid, and the calyx covered with a membranous integument (?).

From Eichwald's figure, we are inclined to place the genus with the Rhodocrinidæ, perhaps in the neighborhood of *Thylacocrinus*, provided we are right in supposing that it has five small underbasals within the ten so-called basals. We take the ten latter, which are said to be tumid, as representing five basals alternating with the five first radials. There are 3 × 5 primary, and evidently two rows of secondary radials, separated by numerous interradial and perhaps interaxillary plates.

Eichwald has referred to it a single species :—

1860. **Condylocrinus verrucosus** Eichwald. Lethæa Rossica, p. 612, Pl. 31, fig. 51. Silurian. Russia.

2. (?) **SCHIZOCRINUS** Hall.

1847. Hall. Palæont. New York, i, p. 81.
1879. Zittel. Handb. der Palæont., i, p. 371 (Stelidiocrinidæ).

The genus was founded upon very imperfect material, but evidently occupies a position near *Glyptocrinus*, if not identical with it. It probably had, like that genus, small or rudimentary underbasals hidden by the column.

Hall describes it with five pelvis plates (our basals); 2 × 5 costals (the first and second radials); 1 × 5 scapulars (the third primary radials); 1 × 5 brachials or arm plates (according to figure a fourth series of primary radials, but probably longitudinally divided, and represented by two plates forming the first series of secondary radials); and above these a double cuneiform arm plate supporting the hand and fingers, we should say a second series of secondary radials, which support the primary arms.

The interradial areæ are composed of several series of two plates each, except the first series which has but one piece, resting in the upper notch between two adjoining first radials. It is not known whether the anal side is distinct, nor has the dome been observed.

Arms short, branching, single jointed. Column round.

These characters, even if correctly interpreted, are not sufficient to distinguish *Schizocrinus* from *Glyptocrinus*. We are inclined to think that the type specimen of *Sch. nodosus* is a young specimen of some *Glyptocrinus*, unless, perhaps, *Schizocrinus* represents palæontologically an earlier stage of the former. The interradial and interaxillary plates seem to be less developed, the arms are short, simple jointed, and the second division of the ray, which in *Glyptocrinus* generally takes place in the body, occurs in the free arms. Hall's second species, still more fragmentary, is probably a very different thing.

Geological Position, etc.—Both species are from the Trenton limestone of New York.

1847. **Schizocrinus nodosus** Hall. Palæont. New York, vol. i, p. 81, Pl. 27, figs. 1 a-p. Trenton limest. Herkimer Co., New York.

1847. (?) **Schizocr. striatus** Hall. Palæont. New York, vol. i, p. 316, Pl. 28, figs. 4 a, b, c. Trenton limest. Middleville, New York.

3. (?) SCYPHOCRINUS Hall (not Zenker, 1833).

(?) CUPULOCRINUS D'Orbigny.)

1847. *Scyphocrinus* Hall. Palæont. New York, vol. i, p. 85.

1850. *Cupulocrinus* d'Orbigny. Prodr. de Paléont., i, p. 23.

(*Scyphocrinus* Zenker, 1833. Beitr. Naturgesch d. Urwald, p. 26, Pl. 4. and Münster, Beitr. iii, p. 112.)

The name being preoccupied by Zenker, d'Orbigny proposed in its place *Cupulocrinus* with *Scyphocrinus heterocostalis* Hall, and a species of *Taxocrinus* as the types.

The form has been generally considered as closely allied to *Schizocrinus*, in which we cannot concur. We think d'Orbigny is correct in placing it with—or near—*Taxocrinus*, but to verify this, better specimens are required, and we will not attempt a generic description from the present material.

(?) 1847. **Scyphocr. heterocostalis** Hall. Palæont. New York, vol. i, p. 85, figs. 3 a-f. Herkimer Co., New York.

4. (?) HADROCRINUS Lyon.

1869. Lyon. Trans. Amer. Philos. Soc., vol. xiii, p. 445.
1879. Zittel. Handb. der Palæont., i, p. 377.
Syn. (?) *Coronocrinus* Hall. Palæont. New York, iii, p. 124.

The name was proposed for certain crinoidal remains, which had been obtained from the Devonian, near Louisville, Kentucky. The specimens were all fragmentary, but enough is preserved to show a great resemblance to *Dolatocrinus*, and it seems to us that this form should be, like *Stereocrinus*, placed subgenerically under it. *Hadrocrinus* differs from *Dolatocrinus* in the smaller size of the basals, and in having only two primary radials; it differs from this and *Stereocrinus* in the numerous bifurcations within the rays, and in having the arms arranged continuously around the body, and not in groups. The genus *Coronocrinus* proposed by Hall, which was founded upon mere fragments, is in all probability identical with *Hadrocrinus*.

According to Lyon, the body is very large and broad, the calyx low vasiform, the dome hemispherical. Basals three, small, hidden by the column, and only seen when viewed from the inner side. Primary radials 2 × 5, the second axillary. Higher orders of radials numerous, each one composed of two series, and the plates all forming a part of the calyx. The uppermost plate excavated, and forming with the dome plates a large ambulacral or arm opening. The openings are numerous, arranged continuously around the body, and are at no place separated by interradial pieces. Interradial areæ composed of few, three or four pieces, which, like all the radial pieces, are comparatively narrow and long, and of very uniform size throughout, thereby producing the great width in the body. It is not known whether the anal area is distinct or not. Interaxillaries two to four or more. Arms unknown. Column round, rapidly tapering downward; perforation round near the calyx, at a distance below pentalobate.

Geological Position, etc.—From the Devonian of Kentucky. We only recognize two of Lyon's species. *Hadrocrinus pentagonus* is very imperfectly known, and in all probability belongs to a very different group.

1869. **Hadrocrinus discus** Lyon. Trans. Amer. Philos. Soc., vol. xiii, p. 448, Pl. 26, fig. a. Corniferous limest., Devonian. Falls of the Ohio.

1869. **Hadrocr. plenissimus** Lyon. Trans. Amer. Philos. Soc., vol. xiii, p. 445, Pl. 26, figs. B 1–3. Corniferous limest., Devonian. Falls of the Ohio, near Jeffersonville, Ind.

LIST OF SYNONYMS, CORRECTIONS AND IMPERFECTLY DEFINED SPECIES.

Abracrinus d'Orbigny.

A. simplex d'Orb., see *Carpocrinus simplex.*

Acanthocrinus Roemer, syn. of *Rhodocrinus.*

A. longispina Roemer, see *Rhodocr. longispina.*
A. nodulosus Hall, see *Rhodocr. nodulosus.*
A. gracilis Hall, see *Rhodocr. gracilis.*

Actinocrinus Miller.

A. abnormis Lyon, see *Megistocr. abnormis.*
A. aculeatus Austin, not sufficiently defined.
A. ægilops Hall, see *Teleiocr. ægilops.*
A. æqualis Hall, see *Batocr. æqualis.*
A. æquibrachiatus McChesney, see *Batocr. æquibrachiatus.*
A. —— var. *alatus* Hall, syn. of *Batocr. æquibrachiatus.*
A. Agassizi Troost. Not defined.
A. althea Hall, see *Teleiocr. althea.*
A. amphora Portlock, syn. of *Amphoracr. Gilbertsoni.*
A. amplus Meek and Worth., see *Periechocr. amplus.*
A. Andrewsianus McChesney, see *Batocr. Andrewsianus.*
A. araneolus Meek and Worth., see *Steganocr. araneolus.*
A. asterias McChesney, syn. of *Batocr. verrucosus.*
A. asteriscus Hall, syn. of *Batocr. æquibrachiatus.*
A. arthriticus Phill., see *Gissocr. arthriticus.*
A. atlas McCoy, see *Amphoracr.* (?) *atlas* Roemer.
A. brevicalyx Rose. Not found the description.
A. brevicornis Hall, see *Megistocr. brevicornis.*
A. brevimanus Angelin, see *Periechocr. brevimanus.*
A. brevis Hall, see *Agaricocr. brevis.*
A. biturbinatus Hall, see *Batocr. biturbinatus.*
A. calyculoides Hall, see *Eretmocr. calyculoides.*
A. calyculus Hall, see *Batocr. calyculus.*
A. calypso Hall, see *Gennæocr. calypso.*
A. canaliculatus Hall, see *Dorycr. canaliculatus.*
A. carica Hall, see *Eretmocr. carica.*
A. caroli Hall, syn. of *Batocr. calyculus.*
A. Cassedayi Lyon, see *Batocr. Cassedayi.*
A. catafractus Aust. Not sufficiently defined.
A. cauliculus Hall, see *Gennæocr. cauliculus.*
A. chloris Hall, syn. of *Actinocr. tenuisculptus.*
A. Christyi Shumard, see *Batocr. Christyi,*
A. Christyi Hall, see *Perieochocr. Christyi.*

A. cingulatus Goldf. Described from detached columns.
A. clavigerus Hall, syn. of *Batocr. similis.*
A. clio Hall, see *Eretmocr. clio.*
A. clivosus Hall, see *Teleiocr. clivosus.*
A. clœlia Hall, see *Eretmocr. clœlia.*
A. clypeatus Hall, see *Batocr. clypeatus.*
A. concavus Meek and Worth., see *Dorycr. concavus.*
A. concinnus Shumard, see *Steganocr. concinnus.*
A. corbulis Hall, see *Eretmocr. corbulis.*
A. corniculus Hall, syn. of *Agaricocr. brevis.*
A. cornigerus Hall, see *Dorycr. cornigerus.*
A. cornigerus Shumard, syn. of *Gennæocr. Kentuckiensis,*
A. cornutus Troost. Not defined.
A. coronatus Hall, *Eretmocr. coronatus.*
A. Correyi Lyon, probably (?) *Agaricocrinus.*
A. costatus Eichwald. Detached column.
A. costatus Bigsby, see *Actinocr. costus* McCoy.
A. crassus Austin. Not defined.
A. cyathiformis Sandberger. Badly defined.
A. decadactylus Portlock (not Goldf.). Insufficiently described.
A. decornis Hall, see *Dorycr. decornis.*
A. delicatus Meek and Worth., the young *Teleiocr. umbrosus.*
A. desideratus Hall, syn. of *Dorycr. Missouriensis.*
A. discoideus Hall, see *Batocr. discoideus.*
A. divaricatus Hall, syn. of *Dorycr. cornigerus,*
A. divergens Hall, see *Amphoracr. divergens.*
A. ——— var. *multiramosus* Meek and Worth., syn. of *Amphoracr. divergens.*
A. dodecadactylus Meek and Worth., see *Batocr. dodecadactylus.*
A. doris Hall, syn. of *Batocr. æqualis.*
A. dubius Eichwald. Detached columns.
A. elephantinus Austin. Not sufficiently defined.
A. eris Hall, see *Agaricocr. eris.*
A. erodus Hall, see *Teleiocr. erodus.*
A. eryx Hall, syn. of *Actinocr. glans.*
A. eucharis Hall, see *Gennæocr. eucharis.*
A. Evansii Owen and Shum., see *Megistocr. Evansii.*
A. expansus Phillips, see *Sagenocr. expansus.*
A. fibula Troost. Catalogue name.
A. fiscellus Hall, see *Agaricocr. fiscellus.*
A. formosus Hall, syn. of *Batocr. discoideus.*
A. gemmiformis Hall, *Eretmocr. gemmiformis.*
A. gibbosus Troost. Catalogue name.
A. Gilbertsoni Miller, see *Amphoracr. Gilbertsoni.*
A. Gilbertsoni de Konink, syn. of *Actinocr. stellaris* de Kon.
A. globosus Phillips, see *Rhodocr. globosus.*
A. glyptus Hall, see *Strotocr. glyptus.*
A. Gouldi Hall, see *Dorycr. Gouldi.*

A. granulatus Goldf. Detached columns.
A. granulatus Austin. Not defined. See *Amphoracrinus.*
A. Hageri McChesney, see *Batocr. Hageri.*
A. helice Hall, see *Agaricocr. helice.*
A. Humboldti Troost. Catalogue name.
A. icosidactylus Casseday, see *Batocr. icosidactylus.*
A. Indianensis Lyon and Cass., see *Batocr. Indianensis.*
A. inflatus Hall, syn. of *Amphoracr. spinobrachiatus.*
A. inornatus Hall, syn. of *Batocr. clypeatus.*
A. insculptus Hall, see *Teleiocr. insculptus.*
A. interradiatus Angelin, syn. of *Periechocr. Lindstromi.*
A. irregularis Lyon and Cass., see *Batocr. irregularis.*
A. Kentuckiensis Shum., see *Batocr. Kentuckiensis.*
A. Konincki Shum., see *Eretmocr. Konincki,*
A. lævis Miller. Detached columns.
A. lævissimus Austin. Not defined.
A. lagina Hall, syn. of *Actinocr. proboscidialis.*
A. laguncculus Hall, see *Batocr. lagunculus.*
A. latus Hall, see *Megistocr. latus.*
A. laura Hall, see *Batocr. laura.*
A. lepidus Hall, see *Batocr. lepidus.*
A. leucosia Hall, see *Eretmocr. leucosia.*
A. liratus Hall, see *Teleiocr. liratus.*
A. locellus Hall, syn. of *Actinocr. reticulatus* Hall.
A. longidigitatus Angelin, see *Periechocr. longidigitatus.*
A. longimanus Angelin, see *Periechocrinus.*
A. longirostris Hall, see *Batocr. longirostris.*
A. longispinus Austin. Not defined.
A. major Angelin. Rhodocrinidæ, genus (?).
A. mammillatus de Koninck (Bigsby). Not seen description.
A. matuta Hall, see *Eretmocr. matuta.*
A. ——— var. *attenuata* Hall, see *Eretmocr. attenuata.*
A. medius Angelin. Rhodocrinidæ, genus (?).
A. Meekii Lyon, see *Macrostylocr. Meekii.*
A. minor Hall, syn. of *Megistocr. brevicornis.*
A. Mississippiensis Roemer, see *Dorycr. Mississippiensis.*
A. ——— var. *spiniger* Meek and Worth., syn. of *D. Mississippiensis.*
A. Missouriensis Shumard, see *Dorycr. Missouriensis.*
A. moniliferus Goldf. Detached columns.
A. moniliformis Miller, see *Periechocr. moniliformis,*
A Mortoni Troost. Catalogue name.
A. multicornis Lyon, see *Centrocr. multicornis.*
A. mundulus Hall, see *Batocr. mundulus.*
A. muricatus Goldf. Detached columns.
A. multibrachiatus var. *echinatus,* see *A. multibrachiatus.*
A. Nashvillæ Troost, see *Batocr. Nashvillæ.*
A. ——— var. *subtractus* White, see *Batocr. Nashvillæ.*

A. nodulosus Goldf. Detached columns.
A. nubilis Angelin, *Periechocr. nubilis.*
A. nyssa Hall, see *Gennæocr. nyssa.*
A. oblatus Hall, syn. of *Batocr. rotundus.*
A. obpyramidalis Winchell and Marcy. Internal cast.
A. olliculus Hall, syn. of *Periechocr. Whitei.*
A. ornatus Hall, see *Physetocr. ornatus.*
A. papillatus Hall, syn. of *Batocr. clypeatus.*
A. Parkinsoni de Koninck (?). Not seen the description.
A. parvus Shumard, see *Dorycr. parvus.*
A. pendens Hall, syn. of *Dorycr. unicornis.*
A. pentagonus Hall, see *Steganocr. pentagonus.*
A. pentaspinus Lyon, see *Centrocr. pentaspinus.*
A. perumbrosus Hall, syn. of *Strotocr. regalis.*
A. pistilliformis Meek and Worth., see *Batocr. pistilliformis.*
A. pistillus Meek and Worth., see *Batocr. pistillus.*
A. planobasilis Hall, syn. of *Amphoracr. divergens.*
A. planodiscus Hall, see *Batocr. planodiscus.*
A. plumosus Hall. Detached arms.
A. pocillum Hall, see *Gennæocr. pocillum.*
A. polydactylus Bonny (not Miller), *Melocr. pachydactylus.*
A. præcursor Hall, see *Dorycr.* (?) *præcursor.*
A. prumiensis Wirtgen and Zeiler, see *Dorycr. prumiensis.*
A. pulcher (Salter MS.) McCoy, see under *Periechocrinus.*
A. pyramidatus Hall, see *Agaricocr. pyramidatus.*
A. pyriformis Ad. Roemer. Not seen description.
A. pyriformis Shumard, see *Batocr. pyriformis.*
A. pyriformis var. *rudis* M. and W., syn. of *Batocr. pistilliformis.*
A. quadrispinus White, syn. of *Amphoracr. divergens.*
A. quaternarius Hall, syn. of *Actinocr. proboscidialis.*
A. ——— *spiniferus* Hall, syn. of *Actinocr. proboscidialis.*
A. quinquangularis Angelin, see *Periechocr. quinquangularis.*
A. quinquelobus Hall, syn. of *Dorycr. cornigerus.*
A. radiatus Angelin, see *Periechocr. radiatus.*
A. ramulosus Hall, see *Eretmocr. ramulosus.*
A. regalis Hall, see *Strotocr. regalis.*
A. regularis Hisinger = *Hypanthocr. regularis.*
A. remibrachiatus Hall, see *Eretmocr. remibrachiatus.*
A. retiarius Phillips. Detached columns.
A. rotundus Yandell and Shum., see *Batocr. rotundus.*
A. rudis Hall, see *Teleiocr. rudis.*
A. rusticus Hall, syn. of *Actinocr. scitulus.*
A. Schultzianus Angelin, see *Periechocr. Schultzianus.*
A. sculptus Miller. Detached columns.
A. sculptus Hall, see *Steganocr. sculptus.*
A. semiradiatus Hall, see *Periechocr. semiradiatus.*
A. senarius Hall, syn. of *Physetocr. ornatus.*

A. securus Hall, syn. of *Actinocr. sexarmatus.*
A. Sillimani Meek and Worth., syn. of *Actinocr. scitulus.*
A. similis Hall, see *Batocrinus similis.*
A. simplex Phillips, see *Carpocrinus simplex.*
A. sinuosus Hall, see *Batocr. sinuosus.*
A. speciosus Meek and Worth., syn. of *Strotocr. regalis.*
A. spinobrachiatus Hall, see *Amphoracr. spinobrachiatus.*
A. spinulosus Hall, see *Dorycr. spinulosus.*
A. steropes Hall, see *Batocr. steropes.*
A. striatus Münster. Not known to us.
A. subaculeatus Hall, see *Dorycr. subaculeatus.*
A. subæqualis McChesney, syn. of *Batocr. discoideus.*
A. subturbinatus Meek and Worth., syn. of *Dorycr. parvus.*
A. subumbrosus Hall, syn. of *Teleiocr. liratus,*
A. subventricosus McChesney, syn. of *Physetocr. ventricosus.*
A. superlatus Hall, syn. of *Megistocr. brevicornis.*
A. symmetricus Hall, syn. of *Dorycr. parvus.*
A. tenuidiscus Hall, see *Periechocr. tenuidiscus.*
A. tenuiradiatus Hall, 1861, see *Teleiocr. tenuiradiatus.*
A. tenuiradiatus Hall, 1847, Palæocrystes.
A. tenuistriatus Phillips. Detached columns.
A. tesseratus Goldf. Detached plates and columns.
A. tesseracontadactylus Goldf., see *Abacocr. tesseracontadactylus.*
A. tesseracontadactylus Hisinger, syn. of *Carpocr. simplex.*
A. themis Hall, syn. of *Actinocr. proboscidialis.*
A. thetis Hall, syn. of *Actinocr. sexarmatus.*
A. thoas Hall, syn. of *Actinocr. reticulatus.*
A. tholus Hall, syn. of *Actinocr. glans.*
A. tricornis Hall, syn. of *Dorycr. unicornis.*
A. trinodus Hall syn. of *Dorycr. parvus.*
A. turbinatus Hall, see *Batocr. turbinatus.*
A. ——— var. *elegans* Hall, syn. of *Batocr. turbinatus.*
A. umbrosus Hall, see *Teleiocr. umbrosus.*
A. unicornis Owen and Shum., see *Dorycr. unicornis.*
A. unispinus Hall, see *Dorycr. unispinus.*
A. urna Troost. Catalogue name.
A. urnæformis McChesney, syn. of *Eretmocr. Konincki.*
A. validus Meek and Worth., syn. of *Steganocr. concinnus.*
A. ventricosus Hall, see *Physetocr. ventricosus.*
A. ——— *cancellatus* Hall, syn. of *Physetocr. ventricosus.*
A. ——— *internodius* Hall, syn. of *Physetocr. ventricosus.*
A. Verneuili Troost, see *Melocr. Verneuili.*
A. Verneuilianus Shum., see *Eretmocr. Verneuilianus.*
A. viminalis Hall, see *Amphoracr. viminalis.*
A. Wachsmuthi White (1862), syn. of *Actinocr. scitulus.*
A. Wachsmuthi White (1880), see *Batocr. Wachsmuthi.*
A. Whitei Hall, see *Periechocr. Whitei.*

A. Whitfieldi Hall, syn. of *Periechocr. Christyi.*
A. Yandelli Shumard, see *Batocr. Yandelli.*

Agaricocrinus Troost.

A. bellatrema Hall, syn. of *Agaricocr. ornatrema.*
A. bullatus Hall, syn. of *Agaricocr. americanus.*
A. corrugatus Hall, syn. of *Agaricocr. pyramidatus.*
A. excavatus Hall, syn. of *Agaricocr. americanus.*
A. nodosus Meek and Worth., syn. of *Agaricocr. americanus.*
A. pentagonus var. *convexus*, see *Agaricocr. convexus.*
A. tuberosus Troost., syn. of *Agaricocr. americanus.*

Alloprosallocrinus Lyon and Casseday.

A. depressus Lyon and Cass. Not sufficiently defined.
A. euconus Meek and Worth., see *Batocr. euconus.*

Amblacrinus d'Orbigny. Not sufficiently defined.

A. rosaceus (Roemer) d'Orbigny, see *Coccocr. rosaceus.*

Amphoracrinus Austin.

A. americanus Roemer, see *Agaricocr. americanus.*
A. bellatrema Hall, syn. of *Agaricocr. ornotrema.*
A. concavus (Actinocr.) Meek and Worth , see *Dorycr concavus.*
A. corrugatus Hall, syn. of *Agaricocr. pyramidatus.*
A. crassus Austin. Insufficiently defined.
A. excavatus Hall, syn. of *Agaricocr. americanus.*
A. granulatus Austin. Not sufficiently defined.
A. inflatus Meek and Worth. (Hall's *Actinocr. inflatus*, 1860), syn. of *Amphoracr. spinobrachiatus.*
A. inflatus (Hall's *Agaricocr.—Amphoracr.—inflatus*, 1861), see *Agaricocr. inflatus.*
A. ornotrema Hall, see *Agaricocr. ornotrema.*
A. planobasilis Hall (Meek and Worth.), syn. of *Amphoracr. divergens.*
A. planoconvexus Hall, *Agaricocr. planoconvexus.*
A. quadrispinus White (Meek and Worth.), syn. of *Amphoracr. spinobrachiatus.*
A. subturbinatus Meek and Worth., syn. of *Dorycr. parvus.*

Aspidocrinus Hall. The root (?) of a crinoid.

A. callosus Hall. Body unknown.
A. digitatus Hall. Body unknown.
A. scutelliformis Hall. Body unknown.

Asterocrinus Lyon (not Münster), syn. of *Pterotocrinus.*

A. capitalis Lyon, see *Pterotocr. capitalis.*
A. coronatus Lyon, see *Pterotocr. coronatus.*

Astrocrinites Conrad (not Cumberland nor Austin), syn. of *Melocrinus.*

A. pachydactylus Hall, see *Melocr. pachydactylus.*

Astropodia Ure, see *Platycrinus*.

Balanocrinus Troost (not Agassiz), syn. of *Lampterocrinus*.
B. inflatus Hall, see *Lampterocr. inflatus*.
B. sculptus Troost, syn. of *Lampterocr. tennesseensis* Roemer.

Batocrinus Casseday.
B. asteriscus Hall (Meek and Worth.), syn. of *Batocr. æquibrachiatus*.
B. clavigerus Hall (M. and W.), syn. of *Batocr. clavigerus*.
B. doris Hall (M. and W.), syn. of *Batocr. æqualis*.
B. formosus Hall (M. and W.), syn. of *Batocr. clypeatus*.
B. inornatus Hall (M. and W.), syn. of *Batocr. clypeatus*.
B. Konincki Shumard (M. and W.), see *Eretmocr. Konincki*.
B. subæqualis McChesney (M. and W.), syn. of *Batocr. clypeatus*.
B. urnæformis Hall (M. and W.), see *Eretmocr. urnæformis*.

Brachiocrinus Hall. Based on detached arm fragments.
B. nodosarius Hall. Arm fragments.

Cacabocrinus Troost, syn. of *Dolatocrinus*.
C. glyptus Hall, see *Dolatocr. glyptus*.
C. ——— var. *intermedius* Hall, see *Dolatocr. glyptus*.
C. lamellosus Hall, see *Dolatocr. lamellosus*.
C. liratus Hall, see *Dolatocr. liratus*.
C. ——— var. *multilira* Hall, syn. of *Dolatocr. liratus*.
C. speciosus Hall, see *Dolatocr. speciosus*.
C. Troosti Hall, see *Dolatocr. Troosti*.

Calathocrinus Hall (not von Meyer), syn. of *Teleiocrinus*.

Castanocrinus Roemer, syn. of *Melocrinus* Goldfuss.

Centrocrinus Austin (not Wachsm. and Spr.), syn. of *Platycrinus*.

Cœlocrinus Meek and Worth. (not *Cœliocr.* White), syn. of *Dorycrinus*.
C. concavus M. and Worth., see *Dorycr. concavus*.

Clonocrinus Oehlert. (not Quenst.), syn. of *Melocrinus*.
C. Bigsbyi Oehlert., see *Melocr. Bigsbyi*.

Condylocrinus Eichwald, see doubtful genera.

Conocrinites Troost. Not defined.
C. Leæ, Troost. Catalogue name.
C. tuberculosus Troost. Catalogue name.

Cophinus Koenig. Detached columns.

Coronocrinus Hall, see *Hadrocr.* (Doubtful genera.)
C. polydactylus Hall. Small fragmentary pieces.

Crumenæcrinites Troost. Not defined.

C. ovalis Troost. Catalogue name.

Ctenocrinus Bronn, syn. of *Melocr.* Goldfuss.

C. bainbridgensis Hall, see *Melocr. bainbridgensis.*
C. decadactylus Goldf., see *Melocr. decadactylus.*
C. lamellosus Eichwald. Detached columns.
C. notatus Eichwald. Detached columns.
C. punctatus Eichwald. Columns.
C. stellaris Roemer, see *Melocr. stellaris.*
C. typus Bronn, see *Melocr. typus.*

Cupellæcrinus Troost. Not defined.

C. Buchii Troost Catalogue name.
C. corrugatus Troost. Catalogue name.
C. inflatus Troost. Catalogue name.
C. lævis Troost. Catalogue name.
C. magnificus Troost. Catalogue name.
C. pentagonalis Troost. Catalogue name.
C. rosæformis Troost. Catalogue name.
C. stellatus Troost. Catalogue name.
C. striatus Troost. Catalogue name.

Cyathocrinus Miller.

C. fasciatus Hall, syn. of *Macrostylocr. Meekii* Lyon.
C. tesseracontadactylus Hisinger (Salter), see *Carpocr. simplex.*

Cystocrinus Roemer. Detached columns.

C. Tennesseensis Roemer. Detached columns.

Cytocrinus Roemer, syn. of *Melocrinus* Goldf.

C. lævis Roemer, see *Melocr. lævis.*

Dæmonocrinites Troost. Not defined.

Decadactylocrinites Owen. Not defined.

Dichocrinus Münster.

D. cornigerus Shum., syn. of *Talarocr. cornigerus.*
D. elegans Cass. and Lyon (not de Kon. and Leh.), see *Talarocr. elegans.*
D. expansus Meek and Worth. (not de Kon. and Leh.), see *Dichocr. polydactylus.*
D. insularis Eichw., see *Hexacr. insularis.*
D. lachrymosus Hall, syn. of *Platyr. subspinulosus* Hall.
D. protuberans Hall, *Pterotocr. protuberans.*
D. sculptus Cass. and Lyon (not de Kon. and Leh.), see *Dichocr. ornatus.*
D. septuosus de Kon., based upon detached plates.
D. sexlobatus Shum., see *Talarocr. sexlobatus.*
D. symmetricus Cass. and Lyon, see *Talarocr. symmetricus.*

Dimerocrinus Phillips.

D. icosidactylus Phill., see *Eucrinus icosidactylus.*
D. oligoptilus Pacht. = *Taxocrinus oligoptilus.*

Dimorphocrinus d'Orbigny, (Pentremites).

D. pentangularis d'Orb., in part *Platycr.* (?) *pentangularis* Miller.

Doliolocrinus Troost. Not defined.

Donacicrinites Troost. Not defined.

D. simplex Troost. Catalogue name.

Echinus dubius Schlotheim, see *Actinocr. lævis*, Miller.

Edwardsocrinus d'Orbigny, syn of *Platycrinus.*

E. ornatus McCoy, see *Platycr. ornatus.*

Eucalyptocrinus rosaceus Hisinger (not Goldf.), see *Marsupiocr. rosaceus.*

Eucrinus Angelin.

E. minor Angelin, see *Anthemocr. minor.*
E. venustus Angelin, see *Anthemocr. venustus.*

Eugeniacrinites hexagonus Münster, see *Platycr. spinosus* Quenstadt.

Forbesiocrinus Pratteni McChesney, see *Melocr. Pratteni* (?).

Geocrinus d'Orbigny, syn. of *Periechocrinus.*

G. moniliformis Miller, see *Periechocr. moniliformis.*

Gilbertsocrinus Phillips. syn. of *Ollacrinus* Cumberland.

G. bursa Phill., see *Ollacr. bursa.*
G. calcaratus Phill., see *Ollacr. calcaratus.*
G. fiscellus Meek and Worth., see *Ollacr. fiscellus*
G. mammillaris Phill., see *Ollacr. mamillaris.*
G. simplex Portlock, see *Ollacr. simplex.*

Glosterocrinus Hall. Not sufficiently defined.

G. elongatus Hall A very imperfect specimen.

Glypytocrinus Hall.

G. armosus McChesney. Described from casts.
G. Baeri Meek, see *Reteocr. Baeri.*
G. basalis McCoy. Insufficiently described.
G. Carleyi Hall, see *Mariacr. Carleyi.*
G. cognatus S. A. Miller, see *Reteocr. cognatus.*
G. Dyeri var. *subglobosus* Meek, see *Glyptocr. subglobosus.*
G. expansus Phill. (d'Orb.), see *Sagenocr. expansus.*
G. gracilis Wetherby, see *Reteocr. gracilis*
G. lacunosus Billings, see *Archæocr. lacunosus.*

G. libanus Safford. Not defined.
G. marginatus Billings, see *Archæocr. marginatus.*
G. O'Nealli Hall, see *Reteocr. O'Nealli.*
G. plumosus Hall. Detached columns and arms.
G. quinquepartitus Billings. Detached columns.
G. Richardsoni Westerby, see *Reteocr. Richardsoni.*
G. siphonatus McChesney. Described from casts.

Goniasteroidocrinus Lyon and Cass., syn. of *Ollacrinus.*
G. fiscellus Meek and Worth., see *Ollacr. fiscellus.*
G. obovatus Meek and Worth., see *Ollacr. obovatus.*
G. tenuiradiatus Meek and Worth., see *Ollacr. tenuiradiatus.*
G. tuberosus Lyon and Cass., see *Ollacr. tuberosus.*

Habrocrinus Angelin, syn. of *Carpocrinus* Müller.
H. anulatus Angel., see *Carpocr. anulatus.*
H. cariosolus Angel., see *Carpocr. cariosolus.*
H. comtus Angel., see *Carpocr. comtus.*
H. decadactylus Angel., see *Carpocr. decadactylus.*
H. grandis Angel., see *Carpocr. grandis.*
H. granulatus Angel., see *Carpocr. granulatus.*
H. lævis Angel., see *Carpocr. lævis.*
H. longimanus Angel., see *Carpocr. longimanus.*
H. ornatissimus Angel., see *Carpocr. ornatissimus.*
H. ornatus Angel., see *Carpocr. ornatus.*
H. pinnulatus Angel., *Carpocr. pinnulatus.*
H. robustus Angel., see *Carpocr. robustus.*
H. tenuis Angel., see *Carpocr. tenuis.*
H. umbonatus Angel., see *Carpocr. umbonatus.*

Hadrocrinus Lyon. See doubtful genera.
H. pentagonus Lyon. Imperfectly known.

Harmocrinus Angelin, syn. of *Stelidiocrinus.*
H. longimanus Angel., see *Stelidiocr. longimanus.*

Hexacrinus Goldfuss.
H. decagonus Goldf. (Bigsby), see *Storthingocrinus.*
H. depressus Austin, syn. of *Hexacr. interscapularis.*
H. eboraceus Hall (Bigsby), see *Platycr. eboraceus.*
H. Eriensis Hall (Bigsby), see *Platycr. Eriensis.*
H fritillus Müller (Bigsby), see *Storthingocrinus.*
H. melo Austin, syn. of *Hexacr. interscapularis.*
H. nodiger Eichwald. Described from detached columns.

Icosidactylocrinites Troost. Not defined.

Lyriocrinus Hall.
L. sculptilis Hall. Described from an indistinct cast.

Macrostylocrinus Hall.

M. fasciatus Hall, syn. of *Macrostylocr. Meekii.*

Mariacrinus Hall (partly syn. of *Melocrinus.*

M. macropetalus Hall (compare with *Corymbocrinus*).
M. nobilissimus Hall, see *Melocr. nobilissimus.*
M. pachydactylus Hall, see *Melocr. pachydactylus.*
M. paucidactylus Hall, see *Melocr. paucidactylus.*
M. penniger Salter (MS.). No description published.
M. stoloniferus Hall. Described from columns.

Marsupiocrinus Phillips.

M. dactylus Hall, see *Lyriocr. dactylus.*
M. dubius Angelin. Evidently an Actinocrinoid.

Medusacrinus Austin. Not defined.

Megistocrinus Owen and Shumard (not Angelin).

M. infelix Winchell and Marcy, see *Periechocr. Christyi* (Hall).
M. Marcouanus Winch. and Marcy, see *Periechocr. Christyi* (Hall).
M. necis Winch. and Marcy. Described from casts.
M. parvirostris Meek and Worth., see *Megistocr. Evansii.*
M. plenus White, syn. of *Megistocr. Evansii.*
M. Whitei Hall, see *Periechocr. Whitei.*

Melocrinus Goldfuss.

M. amphora Goldfuss, syn. of *Amphoracr. Gilbertsoni.*
M. sculptus Hall. Described from basal plates.
M. angustus Angelin, see *Mariacr. angustus.*
M. obconicus Hall, see *Mariacr. obconicus.*
M. lævis Goldf. (not Roemer), syn. of *Melocr. gibbosus.*
M. fornicatus Goldf., syn. of *Melocr. pyramidalis.*

Ophiocrinus Angelin. Preoccupied by Salter, 1852, and Semper, 1868.

Pentagonites Rafinesque. Described from detached plates.

Periechocrinus Austin.

P. anulatus Angelin. Described from detached plates.
P. costatus Austin, syn. of *Periechocr. moniliformis.*
P. geometricus Angelin. Detached plates.
P. globosus Austin. Not defined.
P. grandiscutatus Angelin. Detached plates.
P. lævis Angelin (not Portlock), see *Periechocr. minor* W. and Spr.
P. multicostatus Angelin. Detached plates.
P. undulatus Angelin. Detached plates.

Phillipsocrinus McCoy, see *Melocrinus* and *Actinocrinus.*

P. caryocrinoides McCoy. Probably a malformed *Actinocrinus.*

Phœnicocrinus Austin, syn. of *Carpocrinus* Müller.
  P. simplex Phillips (Austin), see *Carpocr. simplex.*

Pionocrinus Angelin, syn. of *Carpocrinus* Müller.
  P. affinis Angelin, see *Carpocr. affinis.*
  P. elegantulus Angelin, see *Carpocr. elegantulus.*
  P. farctus Angelin, see *Carpocr. farctus.*
  P. pulchellus Angelin, see *Carpocr. pulchellus.*
  P. simplex Phillips (Angel.), see *Carpocr. simplex.*

Platycrinus Miller.
  P. anaglypticus Goldfuss, see *Hexacr. anaglypticus.*
  P. alutaceus Goldf. syn. of *Symbathocr. alutaceus.*
  P. anndixoni Troost. Not defined.
  P. annulatus Goldf., syn. of *Hexacr. anaglypticus.*
  P. antheliontes Austin, syn. of *Platycr. pileatus.*
  P. armatus Münster. (We have not seen the description.)
  P. asper Goldf. (not Meek and Worth.), *Storthingocr. fritillus.*
  P. brevis Goldf., see *Hexacr. brevis.*
  P. Buchii Roemer, see *Hexacr. Buchii (?).*
  P. clytis Hall, syn. of *Platycr. scobina* Meek and Worth.
  P. compressus Eichwald. Pieces of column.
  P. decagonus Goldf., see *Storthingocrinus.*
  P. decoratus F. A. Roemer (?).
  P. depressus Aust. (not Owen and Shum., nor Sandberger), syn. of *Hexacr. interscapularis.*
  P. depressus Goldf., syn. *of Hexacr. interscapularis* Schultze (? W. and S.).
  P. depressus Owen. Not defined.
  P. echinatus Sandberger, syn. of *Hexacr. ornatus.*
  P. ellipticus Austin (not Phill.). Not defined.
  P. elongatus Goldf., see *Hexacrinus elongatus.*
  P. elongatus Phillips, see *Dichocr. elongatus.*
  P. excavatus Hall, syn. of *Platycr. discoideus.*
  P. exsculptus Goldf., see *Hexacr. exsculptus.*
  P. exsertus Hall, syn. of *Platycr. burlingtonensis.*
  P. frondosus Goldf., syn. of *Hexacr. anaglypticus.*
  P. granifer Roemer, syn. of *Hexacr. interscapularis.*
  P. granuliferus A. Roemer, see *Hexacr. granuliferus.*
  P. Goldfussi Münster, syn. of *Hexacr. elongatus.*
  P. Huntsvillæ Troost. Catalogue name.
  P. insculptus Troost. Catalogue name.
  P. insularis Eichwald, perhaps *Hexacrinus* (?).
  P. inornatus McChesney, syn. of *Platycr. burlingtonensis.*
  P. interscapularis Phill. (not Miller), *Hexacr. interscapularis.*
  P. lævigatus Goldfuss, syn. of *Hexacr. anaglypticus.*
  P. Lexæ Lyon, see *Hexacr. Lexæ.*
  P. melo Austin, syn. of *Hexacr. interscapularis.*

P. Milleri McCoy (Pictét), *Cyathocrinus* (?).
P. minutus Schnurr, syn. of *Storthingocr. fritillus.*
P. multibrachiatus Meek and Worth., syn. of *Platycr. discoideus.*
P. muricatus Goldf., syn. of *Hexacr. anaglypticus.*
P. nodulosus Goldf. (not Hall), see *Symbathocr. nodulosus.*
P. nodobrachiatus Hall (1861, not 1858), see *Pl. perasper.*
P. nodosus Wirtgen and Zeiler, see *Culicocr. nodosus.*
P. olla Hall (not de Kon.), syn. of *Pl. Halli* Shum.
P. ornatus Goldf. (not McCoy), see *Hexacr. ornatus.*
P. Oweni Meek and Worth., syn. of *Platycr. regalis* Hall.
P. parvus Hall, see *Cordylocr. parvus.*
P. pentangularis Miller. A Blastoid.
P. Phillipsii d'Orbigny, syn. of *Hexacr. macrotatus.*
P. planus Owen (not Owen and Shum). Not defined.
P. plumosus Hall, see *Cordylocr. plumosus.*
P. polydactylus Troost. Catalogue name.
P. punctobrachiatus Hall (probably not *Platycrinus*).
P. pusillus Goldf., syn. of *Storthingocr. fritillus.*
P. ramulosus Hall, see *Cordylocr. ramulosus.*
P. retiarius Phillips. (We found no description).
P. rosaceus Roemer, see *Coccocr. rosaceus.*
P. rosaceus Goldf., syn. of *Hexacr. callosus.*
P. rugosus Goldf. (not Miller), *Storthingocr. fritillus.*
P. scaber Goldf., *Storthingocr. fritillus.*
P. scobiculata-lineatus Goldf., *Storthingocrinus.*
P. stellaris Roemer, see *Hexacr. stellaris.*
P. striobrachiatus Hall, syn. of *Platycr. corrugatus.*
P. tabulatus Goldf., *Symbathocr. tabulatus.*
P. Tennesseensis F. Roemer, *Marsupiocr. Tennesseensis.*
P. tentaculatus Hall, see *Marsupiocr. tentaculatus.*
P. triacontadactylus, syn. of *Pl. trigintidactylus.*
P. truncatus Hall, syn. of *Platycr. americanus.*
P. ventricosus Goldf., see *Hexacr. ventricosus.*
P. verrucosus White, syn. of *Platycr. pocilliformis.*

Pleurocrinus Austin, see *Platycrinus.*

Pomatocrinus Koenig, MS., not published.

Pradocrinus de Verneuil, syn. of *Periechocrinus.*

P. Baylii de Verneuil, see *Periechocr. Baylii.*

Pterotocrinus Lyon and Casseday.

P. rugosus Lyon and Cass. Not sufficiently defined.

Pyxidocrinus Müller (see our remarks on Actinocrinidæ).

P. prumiensis Müller, see *Dorycr. prumiensis.*

Rhodocrinus Miller.

R. asperatus Billings. Not sufficiently known.
R. Barrisi (var.), *divergens* Hall, syn. of *Rh. Barrisi.*
R. bursa Phillips (Austin). See *Ollacr. bursa.*
R. calcaratus Phillips (Austin), see *Ollacr. calcaratus.*
R. canaliculatus Goldf. Detached columns.
R. costatus Austin. Not sufficiently defined.
R. crenatus Goldf., see *Rhipidocr. crenatus.*
R. echinatus Schlottheim. Detached columns.
R. gigas Billings. Detached columns.
R. granulatus Austin. Not sufficiently defined.
R. gyratus Goldf. Detached columns.
R. melissa Hall, see *Lyriocr. melissa.*
R. mammillaris Phill. (Austin), *Ollacr. mammillaris.*
R. microbasilis Billings, see *Archæocr. microbasilis.*
R. mutabilis Austin. Not defined.
R. pyriformis Billings, see *Archæocr. pyriformis.*
R. quinquangularis Miller. Detached columns.
R. quinquelobus Schultze, see *Eucrinus quinquelobus.*
R. quinquepartitus Goldf. Detached columns.
R. rectus Hall, (Probably a Cystidean.)
R. simplex Portlock (?).
R. tessellatus Steininger, syn. of *Rhipidocr. crenatus.*
R. tortuosus Roemer. Detached columns.

Saccocrinus Hall, syn. of *Periechocrinus.*

S. Christyi Hall, see *Periechocr. Christyi.*
S. semiradiatus Hall. Described from a cast.
S. speciosus Hall, see *Periechocr. speciosus.*
S. tennesseensis Troost. Not defined.
S. Whitfieldi Hall, syn. of *Periechocr. Christyi.*

Sagenocrinus Austin.

S. giganteus Austin. Not sufficiently defined.

Schizocrinus Hall, see "doubtful genera."

Scyphocrinus Hall (not Zenker). Ibid.

Sphærocrinus Meek and Worth. (not Roemer), see *Dorycrinus.*

S. concavus Meek and Worth., see *Dorycr. concavus.*

Sphenocrinus Eichwald. Described from pieces of column.

Strotocrinus Meek and Worthen.

S. asperrimus Meek and Worth., see *Actinocr. asperrimus.*
S. ægilops Hall (M. and W.), see *Teleiocr. ægilops.*
S. althea Hall (M. and W.), see *Teleiocr. althea.*

S. bloomfieldensis S. A. Miller, syn. of *Strotocr. regalis.*
S. ectypus Meek and Worthen, see *Actinocr. ectypus.*
S. erodus Hall, see *Teleiocr. erodus.*
S. insculptus Hall (M. W.), see *Teleiocr. insculptus.*
S. liratus Hall (M. and W.), see *Teleiocr. liratus.*
S. rudis Hall (M. & W.), see *Teleiocr. rudis.*
S. subumbrosus Hall (M. and W.), syn. of *Teleiocr. liratus.*
S. umbrosus Hall (M. and W.), see *Teleiocr. umbrosus.*

Syringocrinus Billings. Imperfectly known.
S. paradoxus Billings. Parts of the arms (?).

Taxocrinus simplex Phill. (Austin), see *Carpocr. simplex.*

Technocrinus Hall.
T. sculptus Hall. Described from basal plates.
T. striatus Hall. Described from basal plates.

Tetramerocrinites Austin. Insufficiently and evidently incorrectly defined.
T. formosus Austin. Undeterminable.

Trematocrinus Hall.
T. fiscellus Meek and Worth., see *Ollacr. fiscellus.*
T. papillatus Hall, see *Ollacr. tuberculosus.*
T. reticulatus Hall, see *Ollacr. reticulatus.*
T. robustus Hall, see *Ollacr. robustus.*
T. spinigerus Hall, see *Ollacr. spinigerus.*
T. tuberculosus Hall, see *Ollacr. tuberculosus.*
T. typus Hall, see *Ollacr. typus.*

Triplariicrinites Goldf. A catalogue name.

Trochicrinites Pander, syn. of *Periechocrinus.*
T. gotlandicus Pander, see *Periechocr. gotlandicus.*

Trybliocrinus Geinitz (?).

Thysanocrinus Hall, syn. of *Dimerocrinus.*
T. aculeatus Hall. Described from fragmentary arms.
T. canaliculatus Hall. Arm fragments.
T. microbasilis Billings, see *Archæocr. microbasilis.*
T. immaturus Hall, see *Dimerocr. immaturus.*
T. liliiformis Hall, see *Dimerocr. liliiformis.*
T. microbasilis Billings, see *Archæocr. microbasilis.*
T. pyriformis Billings, see *Archæocr. pyriformis.*

Turbinocrinus Troost. Not defined.

EXPLANATION OF THE PLATES.

The following letters denote the same parts throughout all the plates.

u = underbasals.
b = basals.
r = radials (r^1 primary radials, r^2 secondary radials, etc.).
i = interradials.
d = interaxillary plates.
cd = central dome plate.
pd = proximal dome plates.
rd = radial dome plates (rd^2 = secondary radial dome plates).
id = interradial dome plates.
dd = interbrachial dome plates.
a — arm plates.
fa = fixed arm plates.
fp = fixed pinnules.
x = anal plates.
xd = anal dome plates.
A = arms.
AO = arm openings.
FR = free rays.
IA = interradial appendages.
RP = respiratory pores.
H = hydrospires.
AT = ambulacral tubes beneath the vault.
G = galleries beneath the vault.
I = interpalmar spaces.
X — anus.
C — column.

EXPLANATION OF PLATE 17.

Fig. 1. *Platycrinus regalis* Hall. The plates in calyx and vault.

Fig. 2. *Ollacrinus tuberculosus* Hall. The plates in the calyx, and those of the interradial appendages and arms.

EXPLANATION OF PLATE 18.

Fig. 1. Extended rim of *Strotocrinus regalis* (dorsal side). All plates below the secondary radials broken away, exposing to view the inner floor of the vault. (This figure in connection with figs. 2, 3, 4, 5, 6, 7, is designed to illustrate the character of a continuous rim and of free rays as extensions of the body, their relations to the arms, and the derivation of the arms from pinnules.)

Fig. 2. *Strotocrinus subumbrosus* Hall. Half of one ray, showing the mode of branching. The medium lines indicate the course of the radial ridges at the surface of the plates.

Fig. 3. *Steganocrinus sculptus* Hall. Showing the free rays and the lateral arms.

Fig. 4. Side view of a portion of a free ray in *Steganocr. sculptus*, showing the ventral covering, and the position of arm openings and respiratory pores.

Fig. 5. Transverse section of the same, showing the form of the inner passage.

Fig. 6. *Reteocrinus Richardsoni* Wetherby. A part of one of the rays within the calyx, showing the fixation of pinnules by means of intercalated plates.

Fig. 7. *Eucladocrinus millebrachiatus* W. and Sp. Ventral side of body, with free rays and lateral arms.

Fig. 8. Showing the position of the apical dome plates in *Batocrinus pyriformis*, a species with a large, almost central anal tube.

Fig. 9. Arrangement of plates in the dome of *Agaricocrinus*.

Fig. 10. Apical dome plates of *Steganocrinus sculptus*.

EXPLANATION OF PLATE 19.

Fig. 1. Vault of *Ollacrinus tuberosus* L. and C., showing the five depressed, oval-shaped groups of small plates opposite the interradial appendages.

Fig. 2. *Batocrinus discoideus*, showing the plates in the calyx. The adjoining plates of the dome added to show the exact position of arm openings and respiratory pores. (The pores are not visible where the arms are attached, but here figured to point out their position.)

Fig. 3. Ventral covering of *Granatocrinus Sayi*, showing the apical and other dome plates, also the extension of this covering over the ambulacral furrows. (O = so-called ovarian openings, f = forked plate, d = deltoid pieces.)

Fig. 4. *Batocrinus discoideus* Hall. Horizontal section through the arm openings and respiratory pores, exposing their passages through the test.

Fig. 5. Natural cast of *Physetocrinus ventricosus*, showing the position of certain pores or pits upon the inner floor of the vault, represented in the cast as small cones.

Fig. 6. Cross-section at midway of *Granatocrinus Norwoodi* Shumard. Showing the hydrospires. (*l* = lancet piece ; *AG* = ambulacral and food passage.)

Fig. 7. *Teleiocrinus* with traces of hydrospires, fig. *a*, portions of two pairs of ambulacral tubes within the radiating tunnels beneath the vault, exposing the upper or ventral side. Fig. *b*, transverse section of the same, indicating two compartments along the tunnels, separated by partition (*p*), the upper containing the ambulacral tubes, the lower the hydrospires. (Compare with fig. 8.)

Fig. 8. A pair of ambulacral tubes in *Actinocrinus glans* Hall, as seen from the inner side. Their exit into the arm passages concealed by a delicate partition (*p*), partly surrounding the tubes, and separating them from the hydrospires; the partition being evidently a continuation of the delicate network which lines the inner floor of the vault. The hydrospires are not preserved, but they probably rested, as in fig. 7, beneath the ambulacral tubes. *AO* represents the arm openings seen from the inner side of the body.

Fig. 9. Internal cast of the vault and free rays in *Actinocrinus multiradiatus*. The ridges radiating to the rays represent furrows at the inner floor of the test.

Fig. 10. Œsophageal network of *Eretmocrinus Verneuilianus* Shum.

Fig. 11. The same organ in *Teleiocrinus rudis* Hall.

Fig, 12. The same in *Batocrinus*, one convolution partly removed.

Fig. 13. The same in a different species of *Batocrinus*.

Fig. 14. A part of the same organ in *Ollacrinus tuberosus*.

Fig. 15. A portion of the network magnified. (From a specimen of *Actinocrinus glans*.)

Fig. 16. *Batocrinus longirostris* Hall. The test partly removed, exposing to view the intervisceral plexus.

Fig. 17. The œsophageal network seen from the base.

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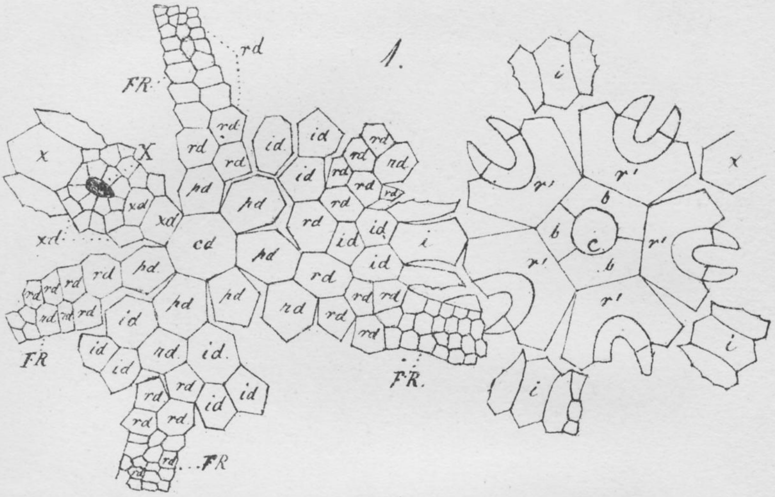
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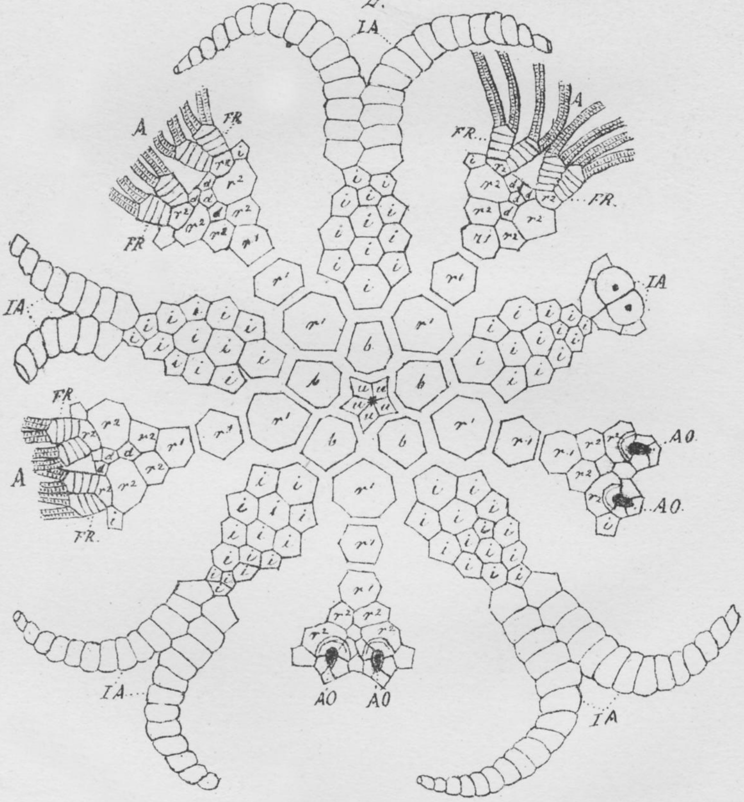
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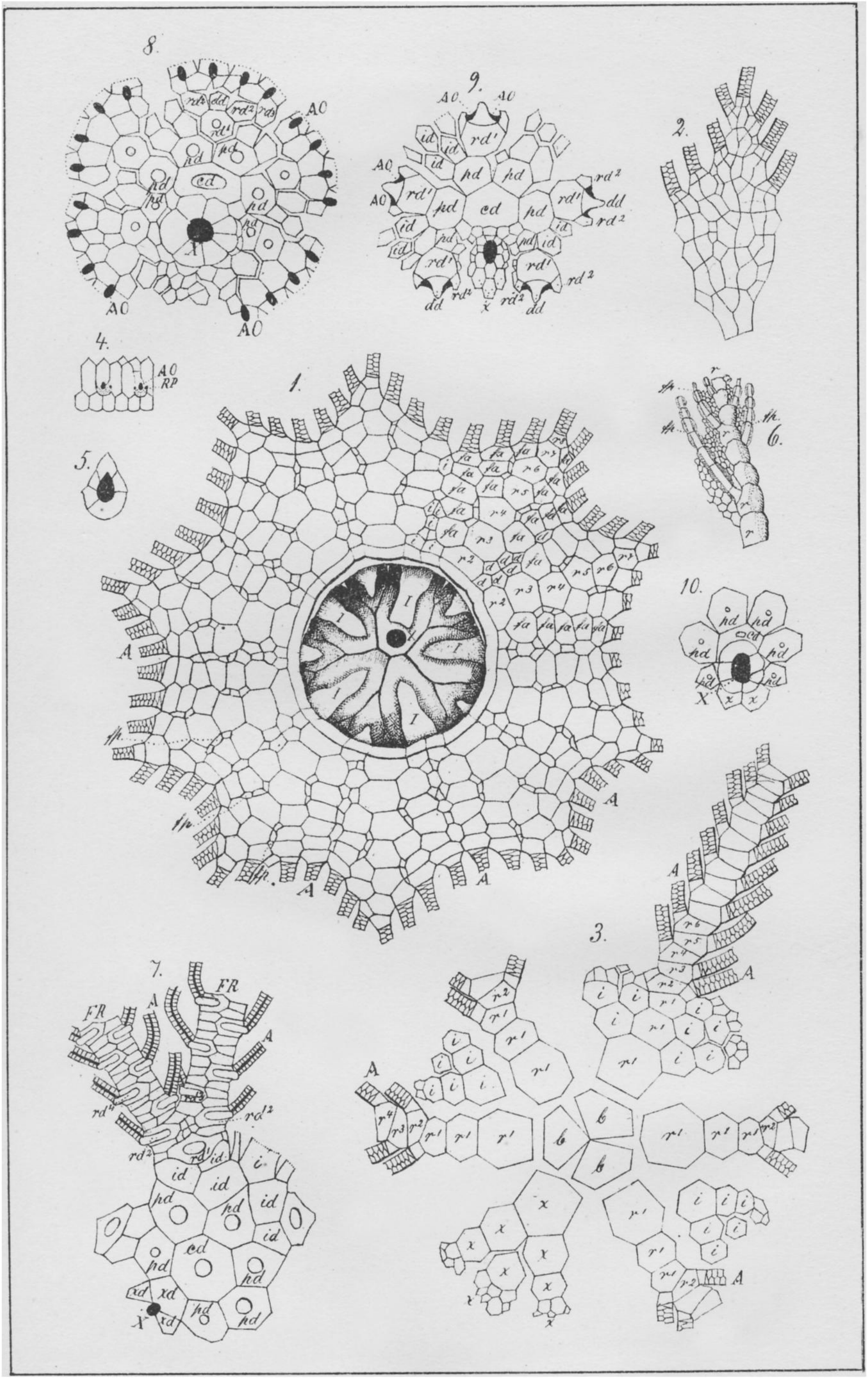
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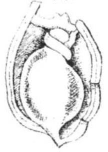

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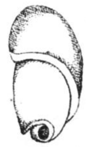

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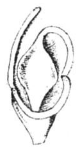

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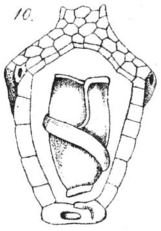

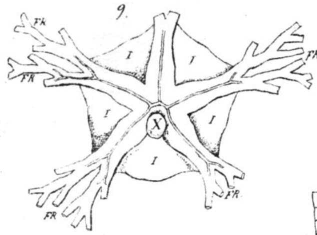
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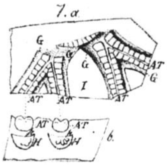
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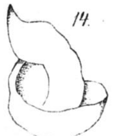

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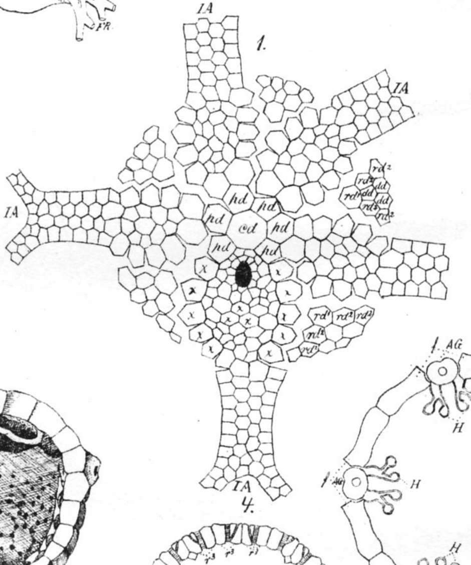
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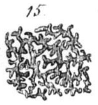

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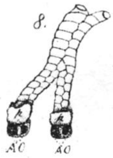

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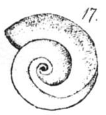

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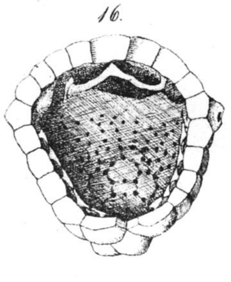

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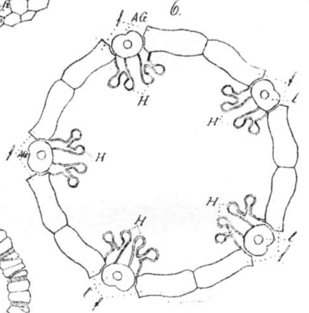

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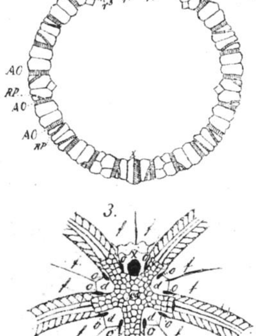

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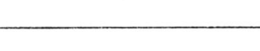

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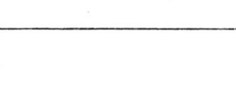

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